metal progress

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Metal Progress

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November . . 1955

Engineering Articles

Industrial Heating

Papers presented before sessions of Industrial Heating Equipment Association, during National Metal Congress, Philadelphia, Oct. 18 and 19, 1955.

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**The coding symbols refer to the ASM-SLA Metallurgical Literature Classification.*

The Curtiss-Wright turbo-compound aircraft engine, showing the valve guide which is cast of an Electro-Alloys anti-galling, heat and abrasion-resistant alloy. This engine is used in many powerful transport aircraft.

This special alloy resists abrasion . . . at high temperature

The original problem arose when Curtiss-Wright Corporation, Wood-Ridge, N. J., required an alloy for valve guides which would reduce oxidation at high temperatures and improve valve stem durability. The Electro-Alloys metallurgical staff tested many alloys, selecting the one proved best for the job.

It is a hardenable, machinable, cast alloy which resists oxidation up to 1800°F (982°C), and it can be drilled or tapped. This alloy has excellent abrasion resistance. It is being used with particular success in valve guide applications. This same alloy is also being used in pump shells, burner nozzles and other parts which must resist heat and severe abrasion.

Their work in new alloy development and extensive experience in the application of existing alloys to solve complex problems qualify the Electro-Alloys engineering and metallurgical staff for tough assignments. If you face the need for high heat-resistant castings, call our nearest representative, or write to us in Elyria.

*Reg. U. S. Pat. Off.

AMERICAN Brake Shoe COMPANY

ELECTRO-ALLOYS DIVISION

6002 TAYLOR ST., ELYRIA, OHIO

Sales offices in: Los Angeles, Oakland, Chicago, Detroit, New York, Cleveland, Philadelphia, Pittsburgh

Forging: COPPER • BRONZE • ALUMINUM • MONEL AND STAINLESS STEEL

Heating for forging 1" stainless hex-head machine bolt blanks with 10,000 cycle TOCCO Induction Heating Unit. Photo — courtesy The H. M. Harper Co.

with TOCCO* Induction Heating

● Naval Bronze, Silicon Bronze, Copper, Aluminum, Monel and all types of stainless steel are heated for forging at the H. M. Harper Co., Morton Grove, Illinois. Regardless of material TOCCO can be profitably applied to brazing, heat-treating and forging operations in almost any metal-working plant.

PRODUCTION UP—In addition to the very important savings in forging dies, TOCCO has increased production to as much as 265% of output possible with former heating methods. On the 1" type 303 Stainless machine bolt blanks shown here TOCCO upped production from 75 to 200 parts per hour, using 35 K.W., 10,000 cycles.

VERSATILE—The same TOCCO machine is used on stock of ⅜" to 1¼" diameter; heated zones vary from ½" to 4". TOCCO'S automatic timing cycles provide complete uniformity of heating throughout both length and cross section—assuring a uniformly high quality product.

●

Why not have a TOCCO Engineer investigate your plant to determine where TOCCO can cut your costs and streamline your production?

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JUST PUSH A BUTTON

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Please send copy of "Typical Results of TOCCO Induction Heating for Forming and Forging".

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As I was saying...

WE ALL have something big to look forward to in November 1957, when the Second World Metallurgical Congress will be held in Chicago with your own A.S.M. again as the sole sponsor of this extraordinary event. Of course, no event of that magnitude comes off without planning far in advance of the opening date, and so your officers and the headquarters staff have been concocting plans for the past year. The first letters of invitation and a booklet describing the Congress are in preparation and will be mailed soon.

The overseas conferees will be invited to participate in a planned industrial tour of two weeks duration preceding the opening of the Congress on Saturday, Nov. 2, in Chicago, or they may enroll in the Congress without taking part in the plant itinerary.

The elapsed time, as compared to the first World Metallurgical Congress, has been reduced by two weeks as a result of this previous experience.

A.S.M. members will be called upon to act as American conferees, paralleling the interests of the overseas visitors.

The overseas conferees will again be top-level technologists actively engaged in some phase of the metal-producing and fabricating industries in both the ferrous and nonferrous field. The conferees will be grouped in the following divisions of the metals industry, both for the purpose of the plant tours and the conferences at the Congress:

1. Steelmaking and Refining. 2. Nonferrous Refining and Fabrication. 3. Ferrous Fabrication (Machining, Forming, Finishing). 4. Heat Treatment. 5. Welding and Joining. 6. Inspection and Testing. 7. Management Problems in the Metals Industry. 8. Education and Research (Private Industry, Government Bureaus, Educational Institutions and Research Institutes). 9. Metallurgical Aspects of Atomic Energy.

All conferees will indicate their primary interest on their preliminary application form, and each of the nine groups listed above will have a separate itinerary and schedule. All will converge on Chicago for the opening date of the Congress, Nov. 2.

The Second World Metallurgical Congress will be held simultaneously with the regular 39th National Metal Congress and National Metal Exposition, and with the Second International Congress of Nondestructive Testing. Travel and hotel accommodations for the overseas visitors will be handled by an accredited travel bureau.

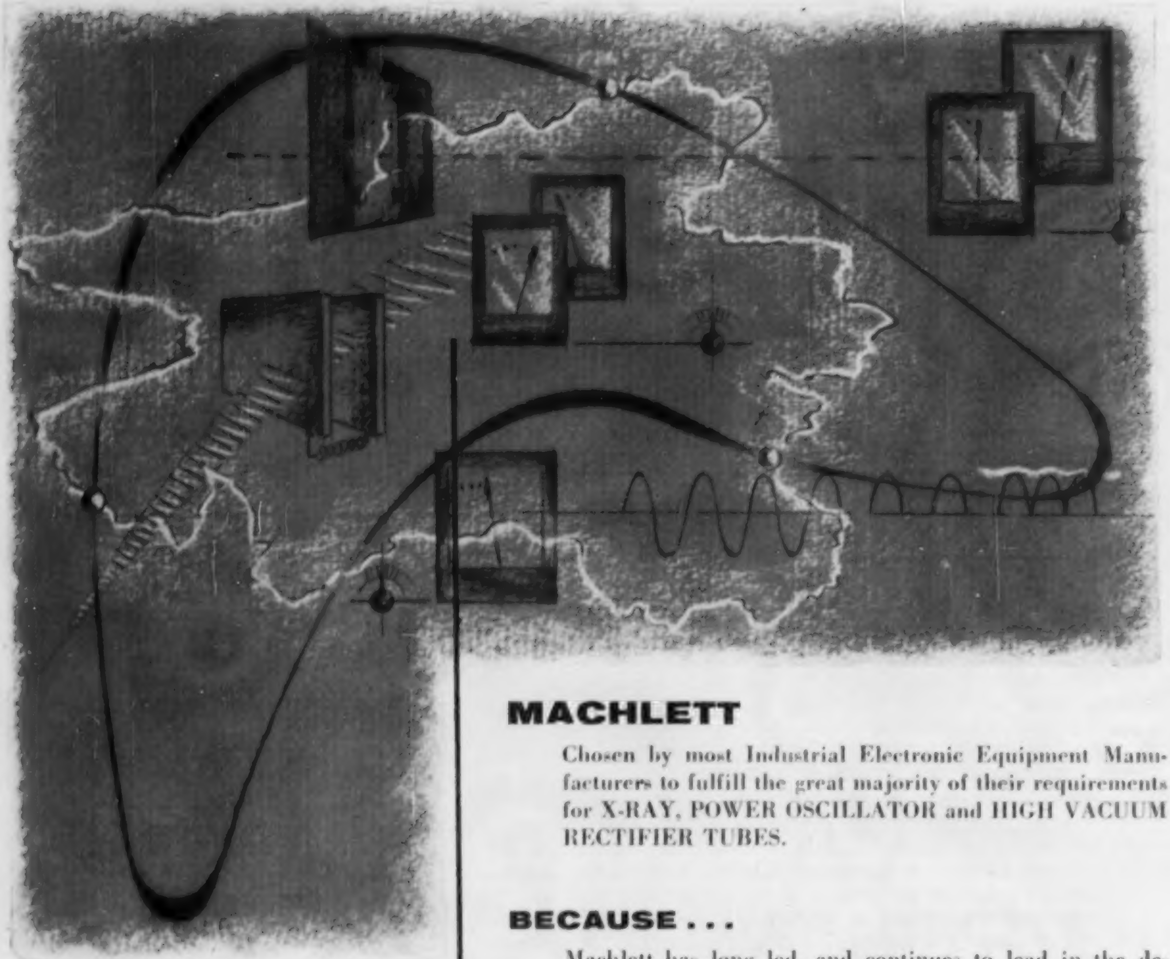
Success of the Second World Metallurgical Congress, equivalent to that of the first, is assured by the acceptance by Dr. Zay Jeffries of A.S.M.'s invitation to again serve as Director-General of the Congress.

During the recent visit of A.S.M. to the Metallurgical Societies Meeting in Europe, advance invitations were orally extended to overseas friends in England, Germany, Belgium, France, Italy, Spain and Sweden to come to America in '57, rekindle established friendship and have a mingling of minds of the brothers in the metal sciences. Let's all hope they all come and enjoy A.S.M.'s hospitality.

Cordially,

Bill

W. H. EISENMAN, *Secretary*
AMERICAN SOCIETY FOR METALS



. . . from the most Complete Line — by a very large margin — of X-Ray, Power Oscillator, and High Vacuum Rectifier Tubes for industrial equipments.

For Industrial X-Ray

Portable Equipments

	Focal Spot	*Max. Oper. Voltage*
PR-120A	1.5mm	120PKV
PR-160A	1.5mm	160PKV
PR-200A	1.5mm	200PKV
PR-260B	2.3mm	260PKV
PR-260C	3.5mm	260PKV
EG-180*	2.8mm	180PKV
EG-250*	3.5mm	260PKV

Very Thin Section Radiography

EG-25A	1.5mm	25PKV
AEG-50A	1.5mm	50PKV
OEG-50A	1.5mm	50PKV

Medium Section Radiography

Aeromax "12"A	1.5mm	110PKV
Hydromax BD	2.3 & 4.2mm	125PKV
Industrial Thermax	2.3mm	150PKV

Thick Section Radiography

IR-220B	2.3mm	220PKV
IR-250B	2.3mm	250PKV
IR-260B	2.3mm	260PKV

Diffraction Analysis

A-2	1.0mm	50PKV
O-2	1.0mm	50PKV

X-Ray Spectroscopy

AEG-50T	....	50PKV
OEG-50T	....	50PKV
OEG-60	....	50PKV

Thickness Gauging

EG-25E	....	25PKV
O-2	....	50PKV
A-2	....	50PKV
AEG-50T	....	50PKV
OEG-50T	....	50PKV
OEG-60	....	50PKV

*Anode Operates at Ground Potential

For R-F Heating Equipments

Tube Type	*Cooling*	*Filament*	*Equip. Power*	*Rated Freq. for Max. Power*
ML-6256	W	T-T	2-3kW	110mcs
ML-6257	W	T-T	2-3kW	110mcs
ML-6258	F-A	T-T	2-3kW	110mcs
ML-5736	F-A	T-T	2-3kW	60mcs
ML-5530	F-A	T-T	3-5kW	110mcs
ML-5666	W	T	5-8kW	25mcs
ML-6420	W	T-T	5-10kW	30mcs
ML-5667	F-A	T	5-8kW	25mcs
ML-6421	F-A	T-T	5-10kW	30mcs
ML-5606	W	T	10kW	1.6mcs
ML-5668	W	T	10kW	5mcs
ML-6422	W	T-T	10-15kW	30mcs
ML-5541	F-A	T-T	10kW	110mcs
ML-6423	F-A	T-T	10-15kW	30mcs
ML-5619	W	T	12-15kW	25mcs
ML-6424	W	T-T	15-20kW	30mcs
ML-5531	F-A	T-T	15-20kW	30mcs
ML-5604	F-A	T	12-15kW	25mcs
ML-6425	F-A	T-T	15-20kW	30mcs
ML-356	W	T-T	20-25kW	25mcs
ML-5658	W	T	20-25kW	25mcs
ML-6426	W	T-T	25-50kW	30mcs
ML-6427	F-A	T-T	25-40kW	30mcs
ML-354	W	T-T	50-75kW	20mcs
ML-5681	W	T-T	50-75kW	30mcs
ML-5682	W	T-T	100-150kW	30mcs

For High Voltage Precipitation High Voltage Power Supplies

			Max. PKV	*Max. MA*
ML-102A	C	T	75	750
ML-141	C	T-T	125	750
ML-5575/100	C	T	150	1000
ML-5576/200	C	T	150	2500
ML-199	C	T-T	110	10000

(*Legend*: W=Water Cooling
F-A=Forced Air Cooling
C=Convection Cooling
T-T=Thoriated Tungsten Filament
T=Tungsten Filament)

Machlett Electron Tubes Available Throughout the World

X-Ray Tubes are available from all X-Ray Equipment Dealers

R-F Heating and Precipitation Tubes are available . . .
in U.S.A.: Graybar Electric Company
in Canada: Dominion Sound Equipments Ltd.
International: Westrex Corporation

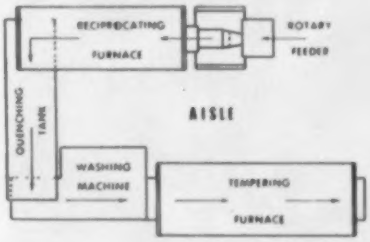
MACHLETT

For Complete Specifications . . . and For Tube Interchangeability Write Machlett Laboratories, Inc., Springdale, Conn.

Engineering Digest of New Products . . .

Automatic Furnace

The American Gas Furnace Co. has announced a range of automatic continuous heat treating installations with production capacities from 100 to 800 lb. per hr. The installations



consist of an automatic rotary feeder, a controlled atmosphere reciprocating furnace, quenching tank, washing machine and tempering furnace. The installation can be made either "in line" or in a "reversing loop" as illustrated.

For further information circle No. 1413 on literature request card, p. 32-B.

Welders

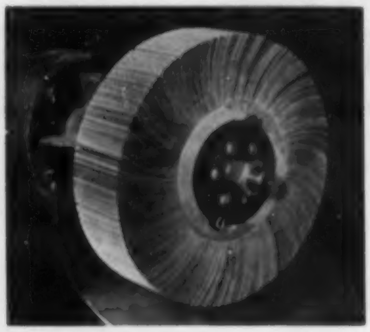
New line of constant-voltage welders of 500, 750, and 1200 amp. has been announced by the Harnischfeger Corp. Voltage may be selected and then remains constant during the welding cycle. The operator sets the

correct rod feed and travel rate to get the desired deposit rate. The constant voltage feature insures that the deposit is uniform; arc voltage, rod speed and travel rate all remain constant. Units have been used for submerged arc, inert gas, semi-automatic, hard surfacing, automatic stud and low-current density welding.

For further information circle No. 1414 on literature request card, p. 32-B.

Polishing

A new polishing and grinding wheel has been announced by Minnesota Mining and Manufacturing Co. It consists of hundreds of pieces of cloth coated abrasives factory-formed into a wheel that can be used on rotary or straight line automatics, or on standard lathes for hand operations. The wheel differs from any other product currently available, in that it



removes stock as part of its polishing action. This abrading-polishing action and the wheel's ability to conform enable it to remove mild draw marks.

For further information circle No. 1415 on literature request card, p. 32-B.

Beta Ray Gage

Pratt & Whitney have announced a new beta ray gage for recording deviations in weight and thickness. It is noncontacting. The gage will detect thickness variations of a few micro inches in steel and can be used on tin, brass and aluminum. Radia-

tion is below the maximum daily amount and when the source is turned off no dangerous radiation is transmitted.

For further information circle No. 1416 on literature request card, p. 32-B.

Hard Facing

A new series of alloy powders for use in Spraywelded hard facing applications has been announced by Wall Colmonoy Corp. They are nickel-chromium-boron alloys and have the following properties:

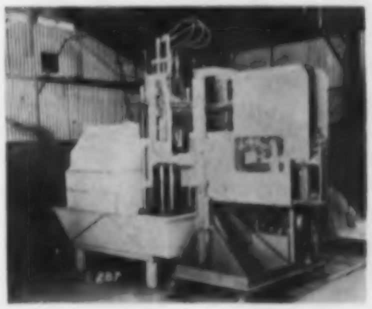
	No. 4	No. 5	No. 6
Hardness, Rockwell C	35 to 40	45 to 50	56 to 61
Specific gravity	8.22	8.14	7.80
Melting point, °F.	2025	1950	1900

Good corrosion resistance, red hardness, weldability, impact and galling resistance are claimed for all three of these alloys.

For further information circle No. 1417 on literature request card, p. 32-B.

Slug Caster

Stroman Furnace and Engineering Co. has announced an automatic slug caster for producing aluminum slugs to be used for aluminum forging or impact extrusion from ingot metal direct from a melting furnace. A slug approximately 1 in. in diameter and 1 in. long could be cast in a multiple cavity die so that 20 to 25 castings

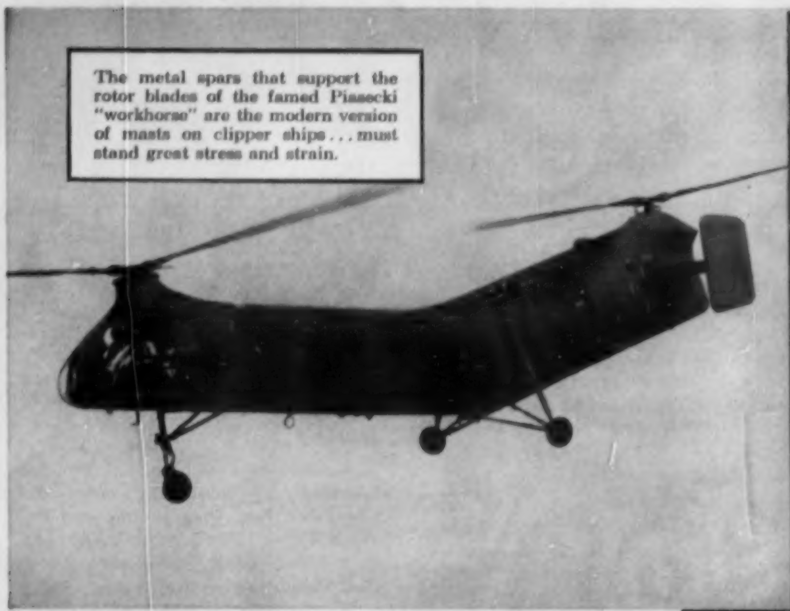


could be made on one stroke of the machine. The cycle of the stroke would run from 30 to 45 sec. giving a potential output of 2000 to 3000 pieces per hour.

For further information circle No. 1418 on literature request card, p. 32-B.

Automatic Heating

A new gas-fired high-speed heating unit for end-annealing of brass tubes has been announced by Gas Appliance



The metal spars that support the rotor blades of the famed Piasecki "workhorse" are the modern version of masts on clipper ships . . . must stand great stress and strain.

To heat treat the Piasecki spars, the Metlab Company of Philadelphia uses a specially designed furnace, unusual techniques . . . and . . . Sun Quenching Oil Light.

For strength and flexibility . . .

20′ Piasecki Rotor Spars Quenched In Sun Quenching Oil Light

It takes real know-how to heat treat the 20 ft long tapered tubing used in Piasecki spars. At the Metlab Company of Philadelphia, Sun Quenching Oil Light plays a major role in the success of this job.

Sun Quenching Oil Light was originally selected by Metlab Company, after lengthy tests, because of its all around quenching ability, low cost and long life. For the Piasecki job, Sun Quenching Oil Light helps give the spars exactly the qualities they need . . . maximum strength with a minimum of distortion. *Proof once more of the ability of Sun Quenching Oil Light to satisfactorily perform difficult oil quench jobs.*

For information about how Sun Quenching Oil Light can perform for you . . . whether in a job shop or on a production line . . . see your Sun representative or write Sun Oil Company, Philadelphia 3, Pa., Dept. MP-11.

SUNOCO

INDUSTRIAL PRODUCTS DEPARTMENT

SUN OIL COMPANY PHILADELPHIA 3, PA.

IN CANADA: SUN OIL COMPANY LTD., TORONTO AND MONTREAL

Service, Inc. Tubes are fed by an automatic hopper to an endless conveyor, which carries them through a heat zone, heating both ends of the tubes simultaneously to a specified length, prior to bending or flaring. The heat zone consists of two high speed end heating furnaces, mounted

on wheels to permit adjustment for various tube lengths and to control the length of the tube section to be heated. Rapid heating in the reducing furnace atmosphere, followed by a water spray quench, prevents oxidation, and produces a sharp line of demarcation between annealed and unannealed portions of the tube. The unit is adjustable to heat from ⅛ to 7 in. of each end of the tubes, and will handle 1 to 2 in. diameters, with overall lengths from 12 to 36 in.

For further information circle No. 1419 on literature request card, p. 32-B.

Induction Heating

A new 3 kw. high frequency induction heating unit has been announced by the High Frequency Div., Lindberg Engineering Co., for brazing, soldering, hardening and other light heat treating applications. It may also be used for melting small quantities of ferrous and nonferrous metals for spectroscopic analysis. The steel cabinet is constructed of angle

frame and 10 gage steel panels to protect internal components from damage and minimize radio frequency radiation. A double compartment shields high frequency oscillator from d.c. power supply and controls. Protection of personnel from high voltage is accomplished by means of interlocks on all access doors. The Model LI-3 is a single station unit with a variable autotransformer to provide stepless variable control of continuous power output from 0 to 3 kw. maximum. Thermal output is 170 Btu. per minute at an output frequency of approximately 400 kc.

For further information circle No. 1420 on literature request card, p. 32-B.

Zinc Electroplating

A series of addition agents for cyanide zinc plating has been announced by Federated Metals Div. The series produces clear, bright deposits directly from the bath and increases the covering and throwing power of zinc baths. They contain no metallic components. Zimax brighteners may serve as a base for post-plate conversion coatings.

For further information circle No. 1421 on literature request card, p. 32-B.

Controller

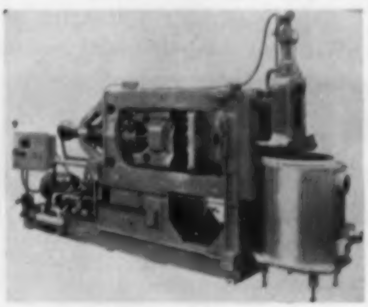
A new pneumatic recording controller for carbon potential has been announced by Surface Combustion Corp. The new pneumatic controller uses the dew point method of carbon potential determination. The unit in-

corporates all the features of the electronic automatic recording controller. The controller automatically compensates for any changes in work surface area as well as in gas analysis while the furnace is operating without manual adjustment.

For further information circle No. 1422 on literature request card, p. 32-B.

Die Casting

Lester-Phoenix, Inc., has announced a 600 ton zinc die casting machine which will cast up to 15¼ lb. of zinc or proportionate weights of lead or



tin. Both shot speed and pressure are adjustable, with a nitrogen accumulator giving high speed injection. Plunger tip is heat treated steel with piston rings. Two fixed shot positions are provided. Die set-up is accomplished by the single hand crank die height adjustment. Die opening is 14 in. The movable platen is 40 in. wide, with a vertical clearance between the beams of 28¼ in. It is supported on hardened steel gibs and can't bend or tip. A 26 x 42 in. opening in the top of the frame means the die space is accessible from all sides.

For further information circle No. 1423 on literature request card, p. 32-B.

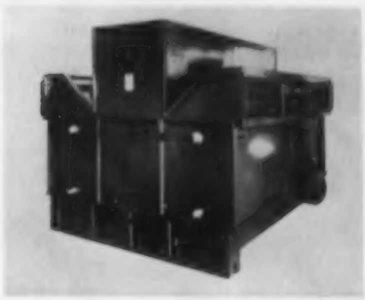
Moisture Control

An instrument to control the moisture content of foundry molding sands has been announced by Harry W. Dietert Co. The Moisture Teller can be located in the foundry. The time required for each individual test need not exceed 3 min.

For further information circle No. 1424 on literature request card, p. 32-B.

Heat Exchangers

Niagara Blower has announced a heat exchanger providing water saving in industrial cooling and giving close control of temperatures. It cools by evaporation and obtains the temperature control by modulating the use of outdoor air. The fluid to be cooled flows through two parallel-mounted coil sections both of which are drenched continuously with a



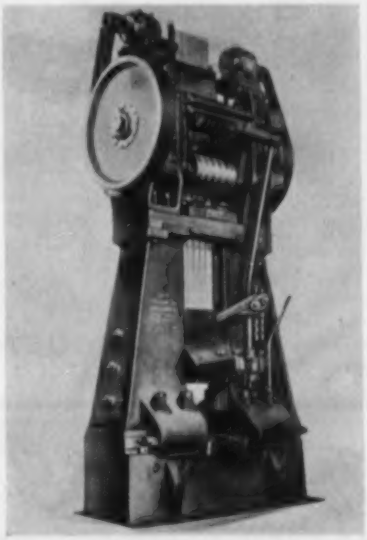
water spray. A portion of this water evaporates while the balance is recirculated by a pump. Air enters through dampered intakes above the coils, travels downward through the sprays and then enters a central plenum between the two sections, at which point the entrained moisture is eliminated. The air then moves upward and a propeller fan ejects it into the atmosphere. The fluid in the cooling coils is cooled to a point close to the atmospheric wet bulb temperature. About 1000 Btu. are transferred, through the wet coil surface to air stream, for every pound of water evaporated. There are four

sizes affording capacities from 7,000,000 to 18,000,000 Btu. per hr. under standard conditions. The units weigh from 9300 to 20,500 lb.

For further information circle No. 1425 on literature request card, p. 32-B.

Forging Hammer

A board drop hammer, rated at 10,000 lb., has been announced by the Erie Foundry Co. The 4-roll design of the lifting head gives longer board life and permits construction of board drop hammers in much larger sizes than the two roll design. This hammer has been equipped with



air operated board clamps which are released by air and set by a weight. Air operating clamps reduce the effort required on the part of the hammer man to operate the hammer. All of its major parts subject to impact are made from cast steel. One of the largest forgings being made in this hammer is a 68 lb. net ring gear, forged in a single impression die.

For further information circle No. 1426 on literature request card, p. 32-B.

Grinding Wheel

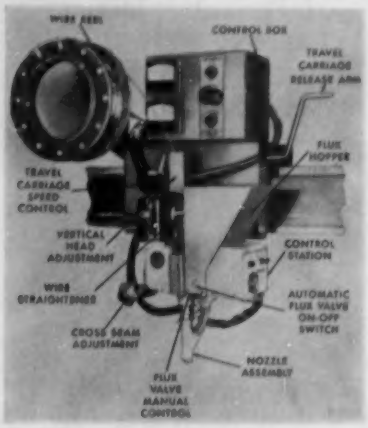
A new high-density, heavy-duty grinding wheel for cleaning stainless slabs or billets has been announced by Electro Refractories & Abrasives Corp. Used in swing frame snagging, the wheel is being manufactured in sizes ranging from 16 to 24 in. in diameter and from 1⅛ to 3 in. thick.

For further information circle No. 1427 on literature request card, p. 32-B.

Automatic Welders

The Lincoln Electric Co. has announced a new line of equipment for hidden or submerged arc welding. The line includes three new welding

heads, new controls and adjustments, new accessories, and two new power sources. The new welding heads offer a choice for either a.c. or d.c. current, field or shop welding, and con-



stant potential or variable voltage power source. New operation controls permit a choice of instantaneous starting, either hot for intermittent welding or cold for precision starting; a choice of variable inching speeds, either slow or fast, away from or to the work; a choice of carriage operation to give stand-still starts, flying starts or manual control. Electrodes in sizes from 3/32 to 7/32 in. are handled by one set of drive rolls. A separate set handles 5/64-in wire.

For further information circle No. 1428 on literature request card, p. 32-B.

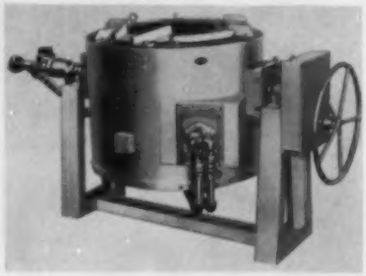
Tubing Steel

A new tubing steel has been announced by the Tubular Products Div. of the Babcock & Wilcox Co. This steel, designated as Croloy 15-15N, was developed for high-temperature, high pressure boiler equipment or other process equipment where strength properties, in excess of those obtainable in the commercial tubular stainless alloys, are required. The base chemical composition is 14.75 to 18.0% Cr, 13.5 to 16.5% Ni, 1.25 to 1.85% Mo, 1.00 to 1.85% W, 0.80 to 1.30% Cb, 2.00% max. Mn and 0.15% max. C. Tensile strength at 1200° F. is 63,700 psi. and yield, 19,200 psi., with 39% elongation in 2 in. and 56% reduction of area. At 1500° F. these values are 35,850, 20,100, 43% and 60%.

For further information circle No. 1429 on literature request card, p. 32-B.

Melting Furnace

Johnston Mfg. Co. has announced a new pot furnace for melting kirksite, lead, aluminum, and other white



metals. It features nozzle mixing burners and automatic controls. A 2000 lb. gas fired, tilting-pot type is shown. It is also available oil fired.

For further information circle No. 1430 on literature request card, p. 32-B.

Descaling

Pangborn Corp. has announced a Rotoblast machine for the high production descaling of hot rolled sheets, plates, and coils. The machine is capable of cleaning both sides of sheet, coil, or plate simultaneously at a cleaning rate up to 360 sq. ft. per side

per min. The machine can be located convenient to production lines. It is equipped with eight standard Rotoblast wheels which are capable of throwing 480,000 lb. of abrasive an hour. One man can handle the cleaning operation.
For further information circle No. 1431 on literature request card, p. 32-B.

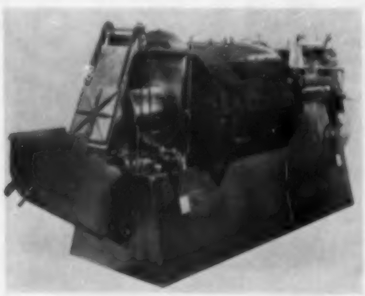
Laboratory Filter

A new portable filter for use in the laboratory, small production shop or pilot plant, has been announced by Bart-Messing Corp. It has a capacity of 250 gal. per hr. and can be used with either the new annular element or a porous stone element, for either acid or alkaline solutions. The filter

can be cleaned in 5 min. After the hand tightened tank cover is removed, the entire element lifts out so that it can be washed to remove sludge. It is furnished with stainless steel and rubber-lined components, or all iron parts.
For further information circle No. 1432 on literature request card, p. 32-B.

Tubular Furnace

A new furnace, designed with a tubular muffle, has been announced by the Pacific Scientific Co. Although intended for high temperature cop-



per and silver brazing of stainless steels, this furnace can be used for annealing, sintering and general heat treating work. Any type of protective atmosphere may be used, including pure, dry hydrogen. It is available in various size retort diameters and lengths, and with temperatures to 2100° F. and can be furnished with either pusher-type work feed, or equipped with a conveyor belt feed for continuous operation.
For further information circle No. 1433 on literature request card, p. 32-B.

Control Instruments

The small, compact Model 292 series Capacitrol has been announced by Wheelco Instruments Div. for accurate indicating and instantaneous control in the process industries. Both the temperature measuring system and the control chassis are of plug-in design.

The balancing adjustment for tuning the alignment index and indicating pointer to exact coincidence, plus adjustment of anticipatory action cycle time, and control setting are all on the front panel.
For further information circle No. 1434 on literature request card, p. 32-B.

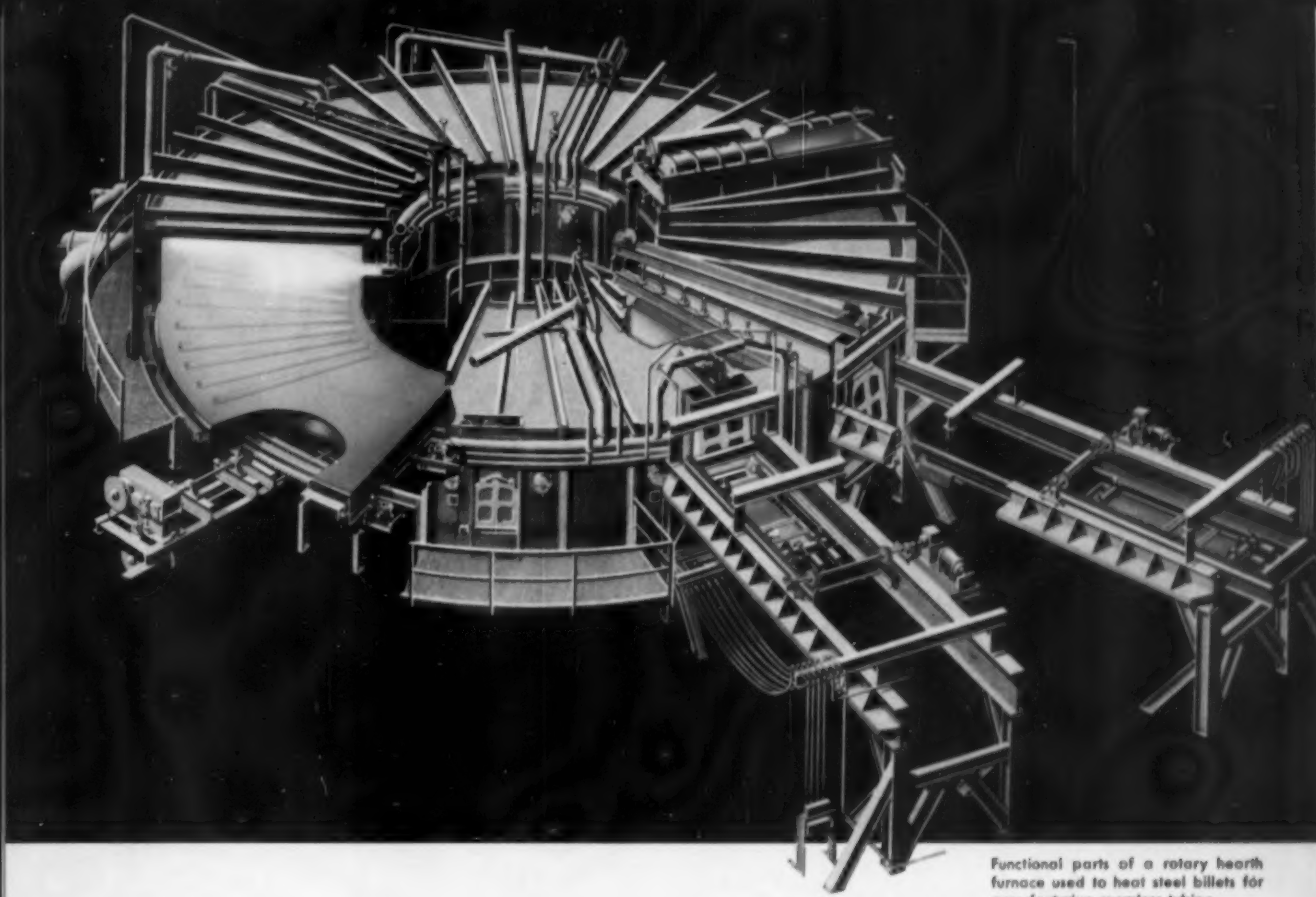
Vapor Degreaser

Rectangular shaped vapor spray degreasers for larger sized parts and heavier work loads have been announced by Baron Industries. These

machines are fabricated of 12 gage and 3/16 in. plate, and have a fused phenolic interior coating. New models have a full water jacket, offset coil condenser and complete manual spray equipment and come in two sizes.
For further information circle No. 1435 on literature request card, p. 32-B.

Electroplating Timers

Improved new models for precision timing of short cycle precious metal electroplating are announced by Technic, Inc. They work without interruption of current. They start timing automatically when work contact is made, and automatically reset themselves when work contact is broken, requiring no manual effort after the required time cycle is set.



Functional parts of a rotary hearth furnace used to heat steel billets for manufacturing seamless tubing

Increase Productivity, Save Space, And Cut Fuel Costs With Salem-Brosius Rotary Hearth Furnaces

Most large rotary hearth furnaces in the world have been designed and built by Salem-Brosius or its licensees. Salem-Brosius developed the large rotary hearth furnace and continuously has improved its design and construction.

Salem-Brosius rotary hearth furnaces are in use today for production heating and heat treating carbon and alloy steel bars, slabs, round and square billets, shell stock and forging stock; and similar products in non-ferrous metals such as copper and brass.

The rotary type furnace saves floor space. Fuel efficiencies and economies are unequalled by any other type of industrial furnace. Heating is rapid and uniform. Charging and discharging is mechanical; and automaticity of control drastically cuts labor costs. A Salem-Brosius rotary hearth assures the minimum of maintenance and repair costs. These benefits spell higher furnace output, less downtime, lower production cost—and greater profit to you, the user.

The rotary hearth is but one of the many types of Salem-Brosius furnaces—furnaces of superior design and construction—furnaces that help improve your product and turn it out at a lower cost. If your plant modernization plans call for heating or heat treating furnaces of any kind, call on Salem-Brosius.

Other Salem-Brosius products include forging manipulators, furnace charging and discharging equipment, hot materials handling equipment, large gas main valves, blast furnace clay guns, and a long list of special machinery and auxiliary furnace equipment. A Salem-Brosius engineer will be glad to help you with problems involving any of this equipment, or any special equipment that must be tailored to your needs. Write to us.

SALEM-BROSIUS, INC.

CARNEGIE, PENNSYLVANIA

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ZEISS Metallurgical Microscope

WITH AN INVERTED STAGE

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Ideal as a supplementary tool for metallographs

Permits examination of samples in same position as with metallograph

The Zeiss Metallurgical Microscope has all of the optics below the stage (Le-Chatelier principle) and permits placing of samples with their polished surface directly on the stage. Previous alignment on the section press is not required. Other features include a built-in illuminant (satisfying the Koehler principle), low positioned coarse and fine adjustments on same spindle, inclined eyepiece, tube quick-changing device for quickly changing monocular or binocular tubes, resilient mounts for all high-powered objectives (protects front lens), sliding type stage which permits minute adjustments, and availability of accessories for photomicrographic work. The integral 6V, 15W low-voltage lamp is designed to handle photomicrography with the miniature camera in addition to the regular viewing work. Both monocular and binocular tubes can be used on the metallurgical microscope; the binocular tube will not affect total magnification. Construction of objectives and eyepieces give total magnification of 40x, 100x, 250x, 630x and 1000x when objectives 4x, 10x, 25x, 63x and 100x are used with 10x eyepiece.

Furnished with adjustment controls, built-in illuminant, blue filter, plane-glass vertical illuminator, centering type visual field stop, tube quick-change device, quintuple revolving nosepiece, circular sliding stage, binocular inclined tube, 6V, 15W filament lamp, neutral filter, variable transformer, achromat objectives 4/0,10 o.D., 10/0,25 o.D.; achromat 25/0,45 o.D. and 40/0,65 o.D. with resilient mount, neofluar objective 63/0,90 o.D. with resilient mount, 2 compensating eyepieces K x 6,3, and 2 compensating plano eyepieces KPL x 16.

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Lists latest equipment for chromatographic and electrophoresis work, including fraction collectors, migration chambers, densitometers, spectrophotometers, etc.

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Chromel-Alumel thermocouple alloys are unconditionally guaranteed to register true temperature—e.m.f. values within close specified limits . . . ±4°F. from 0° to 530°F.; ±¾% at operating temperatures from 531° to 2300°F.

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They're highly resistant to oxidation, extremely sensitive to temperature variations. And they maintain their fine accuracy over a wider range of temperatures for far longer periods of time than any other base metal material.

FOR ECONOMY!

Despite their finer accuracy, higher temperature range, and longer useful life, Chromel-Alumel thermocouple wire costs the user no more than ordinary base metal materials . . . and in many cases, they actually cost less!

Ask for them by name! Your instrument manufacturer or pyrometer service company can supply your immediate requirements for plain or insulated wire and assembled couples. So ask for them by name . . . "Chromel-Alumel" thermocouples . . . trade names you can trust!

Chromel-Alumel thermocouple alloys are produced exclusively by

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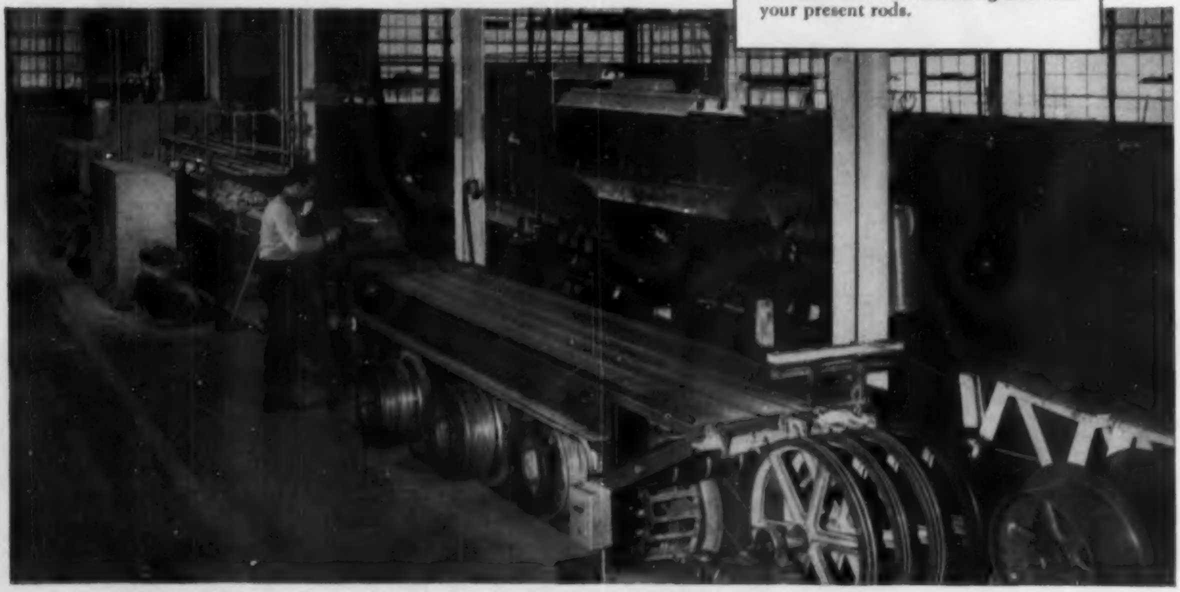
Why another plant converted to "HOT RODS" 100%

J. Bishop & Company Platinum Works reports CRYSTOLON* heating elements outlast others by 3-to-1 in Drever furnaces

CRYSTOLON Heating Elements, or "Hot Rods", are a typical Norton ℞ — an expertly engineered refractory prescription for greater efficiency and economy in electric furnace and kiln operation. Made of self-bonded silicon carbide, each rod has a central hot zone and cold ends. Aluminum-sprayed tips and metal-impregnated ends minimize resistance and power loss. Available in standard sizes and interchangeable with your present rods.



One of the Three Drever Electric Furnaces at the Frazer, Pa., tube mill of J. Bishop & Company Platinum Works, specialists in small diameter stainless steel tubing (.008" to 1" O.D.), tubular fabricated parts, surgical instruments and refiners of precious metals.

Wherever it uses silicon carbide heating elements — as in its Drever electric furnaces — J. Bishop & Company has changed over completely to "Hot Rods."

The reason: other elements lasted only 6 months — *"Hot Rods" averaged 18 months' service life!*

More and more, this 3-to-1 longer life of Norton CRYSTOLON elements is becoming recognized for the truly sensational performance that it is — and a constantly growing number of economy-minded electric furnace operators are taking advantage of it.

But there's a good deal more to this benefit-story. The longer life of "Hot Rods" means you save on element costs — because you use less of them. Also, fewer changes of elements and voltage taps mean greatly reduced maintenance, and a much smoother production flow.

Get Further Facts

on how "Hot Rods" can improve and economize your own electric furnace or kiln operations. Send for the big illustrated booklet, "Norton Heating Elements." NORTON COMPANY, Refractories Division, 332 New Bond Street, Worcester 6, Mass.

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Expiration of the predetermined time cycle is signalled by red light and buzzer.

For further information circle No. 1436 on literature request card, p. 32-B.

High-Carbon Electrodes

High carbon electrodes for manual and automatic application have been announced by Pacific Welding Alloys. Those for manual application are composed of high-carbon wire and will deposit a carbon ratio of 0.60 to 0.70. This electrode is suited for any type of build-up work. Application is by either a.c. or d.c., straight polarity. For automatic use, a high-carbon automatic wire can be applied with either submerged or open arc.

For further information circle No. 1437 on literature request card, p. 32-B.

Temperature Control

A new indicating temperature control has been announced by Burling Instrument Co. Designed for both laboratory and industrial use, it combines an independent dial thermometer with a differential expansion-type

temperature control. Several adjustable temperature ranges are offered, including 150 to 750° F. Control is obtained by the differential expansion of two concentric tubes actuating a snap-acting switch through a lever.

For further information circle No. 1438 on literature request card, p. 32-B.

Electrostatic Spraying

Scientific Electric has announced a new ionic high potential power supply for electrostatic paint spraying. It is furnished as a two-piece, remote-controlled unit. The power supply unit itself is furnished in a heavy-gage steel tank which is usually mounted above the spray booth out of reach of the operator. The control unit, which is designed for wall mounting, is supplied in a separate cabinet and incorporates an electronic spark-guard for safeguard against arc-overs. The power supply unit can produce a peak of 140 kv.

For further information circle No. 1439 on literature request card, p. 32-B.

The World's Largest Heating Element

- *Outside Diameter:* **2⅜"**
- *Overall Length:* **Up to 105"**
- *Heating Section:* **Up to 72"**

GLOBAR® AT TYPE ELEMENT

Goodbye to old quench and temper methods!

SEE HOW

Martempering & Austempering CUT COSTS

FOR THESE LEADING MANUFACTURERS!

Shown here are typical examples of important production savings made possible by Ajax Electric Salt Bath martempering and austempering. And there are hundreds more!

Here, briefly, are the reasons for the outstanding superiority of this method: *First cost of equipment is only 1/2 to 1/5 that of any other conventional system!* Distortion is so negligible that parts can usually be finish machined *before* hardening. Final grinding is seldom necessary. Scale, decarb and quench cracks are avoided. Ductility is increased.

WRITE FOR TECHNICAL BULLETIN #500, *"The Present Status of Austempering and Martempering" — also list of documented case histories of martempering and austempering installations covering a wide variety of industries.*

$50,000 Saved ANNUALLY!

Austempering this well-known electric shaver head (0.003" thick) in an Ajax furnace scored a $50,000 a year saving over conventional quench and temper methods! Austempering produced tougher heads. Rejects due to cracks were reduced from 3.6% to .05%. Uniform hardness is obtained. Distortion is easily held within specified limits.

Grinding TIME Cut 80%

Martempered in Ajax furnaces and drawn to Rc 62-63, these SAE-52100 bearing races show an average out-of-round distortion of only 0.002-0.003" in heat treating. Grinding time was reduced from 50 minutes to less than 10 minutes per race.

One Man HANDLES ENTIRE Production

Lawn mower blades (SAE-1065) are austempered in a fully mechanized Ajax salt bath line to produce the critical combination of Rc 48-52 PLUS high ductility. Finished blades can be bent to horseshoe shape without cracking . . . and they're tough enough to cut nails! Production is 550 blades an hour. One man handles the entire job!

Zero Cracks AND Higher Rc

Section size of this high alloy valve plate varies from ½" to 1⅝". Conventional oil quench and temper methods failed to produce Rc 58-60 without cracking. Martempering and drawing in Ajax salt baths produced a hardness of Rc 60-64 . . . WITHOUT CRACKS!

AJAX HULTGREN electric SALT BATH furnaces

AJAX ELECTRIC COMPANY 910 Frankford Ave., Philadelphia 23, Pa.

Associated Companies: Ajax Electric Furnace Corp. • Ajax Electrothermic Corp. • Ajax Engineering Corp.

What's New in Manufacturers Literature . . .

1454. Abrasion Tester
Bulletin 5409 on new model standard abrasion testing set describes machine and its operation. *Taber Instrument Corp.*

1455. Abrasive Wheels
Operating suggestions and recommended wheels for finishing stainless. *Manhattan Rubber Div.*

1456. Air-Gas Mixer
Bulletin L-700 gives engineering and application data on air-gas proportional mixer. *Eclipse Fuel Eng'g*

1457. Alloy Chart
Comparison of AISI, SAE, ACI, AMS, WAD and PWA chromium and chromium-nickel stainless specifications. *Cannon-Muskegon*

1458. Alloy Steel
207-page book gives more than 50 complete case histories of alloy steel usage. *Climax Molybdenum*

1459. Alloy Steel
14-page bulletin on two chromium-nickel alloy steels. Properties, working instructions, heat treatment, recommended uses. *Carpenter Steel*

1460. Aluminum Alloys
Selector gives the specifications for major aluminum alloys and condition used in sand and permanent mold castings. *Howard Foundry*

1461. Aluminum Alloys
Folder gives properties, fabricating characteristics, applications and size ranges of each alloy. *Peter A. Frasse*

1462. Aluminum Die Castings
Bulletin on design and manufacture of aluminum die castings. *Hoover Co.*

1463. Aluminum Sheet
New wall chart gives weight and bend data on aluminum sheet in standard alloys. *Kaiser Aluminum & Chemical Sales*

1464. Aluminum Strip
20-page booklet on how it is made, sizes and weights of coils. Technical data on aluminum alloys used. *Scovill*

1465. Aluminum Welding
Data on chemical composition of aluminum welding rods and electrodes. *Arcos*

1466. Ammonia Dissociators
Bulletin on dissociating process gives advantages of ammonia as controlled atmosphere. *Sargeant & Wilbur*

1467. Annealing
Reprints of article on continuous annealing of stainless steel sheets in roller hearth furnace. *Gas Machinery Co.*

1468. Annealing
12-page bulletin on short cycle annealing for cold extrusion of steel. *Selas Corp.*

1469. Atmosphere Furnace
Information on mechanized batch-type atmosphere furnaces for gas cyaniding, gas carburizing, clean hardening or carbon restoration. *Dow Furnace*

1470. Atmosphere Furnace
12-page bulletin on electric furnaces with atmosphere control for hardening high speed steel. *Sentry*

1471. Atmospheres
New 12-page bulletin on use of protective atmospheres to prevent deterioration of metals during various heat treating processes. *General Electric*

1472. Automation
Two articles on automation for modern heat treating in Heat Treat Review, Vol. 7, No. 2. *Surface Combustion*

1473. Barrel Finishing
32-page handbook on compounds for descaling, deburring, coloring, metal cleaning and rust inhibition. *Lord Chem.*

1474. Bearings
4-page bulletin on plastic bearing materials. *Dixon Corp.*

1475. Beryllium Copper
16-page booklet on applications and properties of beryllium copper. *Beryllium*

1476. Black Oxide Coatings
8-page booklet on black oxide coatings for steel, stainless steel and copper alloys. *Du-Lite*

1477. Brass
80-page book on properties and uses of brass forgings, sand castings, rods and machinings. *Mueller Brass*

1478. Brazing
Bulletin 124—on salt bath brazing process—shows how it it possible to substitute brass for copper and develop joints of adequate strength for most steel assemblies. *Ajax Electric*

1479. Brinell Machine
Data on semi-automatic Brinell testing machine. *Detroit Testing Machine*

1480. Buffing Compounds
Bulletin T-5 on buffing, liquid abrasive, cutting, coloring compounds. *Globe Compound Co.*

1481. Bulb Thermometers
44-page catalog covers selection data, recorders and indicators, controls, psychrometers, bulbs, tubing and fittings. *Minneapolis-Honeywell*

1482. Burner Nozzles
Bulletin H-15 on open blast burner nozzles for air/gas mixtures. *Eclipse Fuel Engineering*

1483. Castings
12-page booklet on casting costs and basic considerations in making good castings. *Herbert A. Reece and Assoc.*

1484. Carbon and Graphite
20-page catalog on carbon and graphite applications in metallurgical, electrical, chemical, process fields. *National Carbon*

1485. Carbon Control
Bulletin C-22 and reprint on Carbotronik for automatic control of carbon potential of atmospheres. *Ipsen*

1486. Carbon Control
Bulletin SC-168 on system for automatically controlling carbon potential in continuous and batch furnaces. *Surface Combustion Corp.*

1487. Carbon Control
Technical report on instrument for control of carbon potential of furnace atmospheres. *Lindberg Eng'g*

1488. Carbonitriding
Bulletin 241 on gas-fired radiant-tube furnace for carbonitriding and other heat treating. *Lindberg Engineering*

1489. Carburizing
Bulletin on carburizers for pack carburizing. *Park Chemical*

1490. Carburizing Salts
Folder on salts for liquid carburizing. *Swift Industrial Chemical*

1453. High Strength Steels

A group of articles on ultra high-strength steels for use in aircraft applications are assembled in this 74-page book. They are written by experts from several steel producing and aircraft companies. Subjects discussed are: composition and heat treatment of high strength steels; the development of steel for use at

high strength levels; development of a steel for the 280,000 to 300,000 psi. tensile-strength bracket; processing of high-strength steel parts; processing of highly heat treated steel; design considerations in the use of ultra high-strength alloy steels in aircraft. The book contains a profusion of tables and charts giving test results, properties, compositions and other data on these steels. *International Nickel*

1491. Ceramic Products
16-page booklet gives applications of porcelain, stoneware, graphite, alumina, in chemical equipment. *General Ceramics*

1492. Chromate Finishing
File on chromate conversion coatings for prevention of corrosion and paint-base treatment of nonferrous metals. *Allied Research Products*

1493. Chromium Plating
4-page bulletin on new "crack-free" chromium plating process. *United Chromium*

1494. Cleaners
Bulletins on di-phase cleaners, specifications, equipment, advantages. *Solventol*

1495. Cleaning
Bulletin on equipment for cleaning and pickling of shell cases and other ordnance items. *Alvey-Ferguson*

1496. Cleaning
32-page booklet on alkaline, solvent, emulsion, acid phosphate cleaning. *E. F. Houghton*

1497. Cleaning
24-page booklet on use of solvent detergents for removing carbon, grease, dirt and paint. *Oakite*

1498. Coating
New 4-page booklet on spray coating for metals that preserves chemically clean surfaces. *Fidelity Chemical Products*

1499. Cobalt Alloy
12-page booklet, "Haynes Alloy No. 25", tells of the unique properties of this cobalt-base alloy. *Haynes Stellite*

1500. Cold Rolled Steels
32-page booklet on stainless, alloy and carbon spring steels, and other specialties. Melting, temper, finishes. *Crucible Steel*

1501. Combustion Control
20-page booklet on combustion of various fuels and portable instrument to measure content of oxygen and combustibles. *Cities Service Oil*

1502. Compressors
12-page bulletin 126-A on application of turbo compressors to oil and gas-fired equipment used in heat treating, agitation, cooling, drying. Performance curves, capacities. *Spencer Turbine*

1503. Controlled Atmospheres
Bulletin 753 on generator for atmospheres for hardening, brazing, sintering and annealing carbon steels. *Hevi Duty*

1504. Controllers
12-page booklet on temperature controls and special purpose controllers. Operation, design, installation. *Assembly Products, Inc.*

1505. Controllers
16-page educational bulletin No. 9 gives data, operation diagrams, schematic drawings of capacitrols. *Wheelco Instruments*

1506. Copper Alloys
40-page handbook on phosphor bronze, nickel silver, cupro nickel, beryllium copper. *Riverside Metal*

1507. Copper Alloys
48-page book contains tables of alloys with composition, typical uses, general, working, mechanical, electrical properties, hardness, ASTM specification numbers. *Revere*

1508. Copper Alloys
6-page booklet on copper-base alloy castings. Foundry practice. Corrosion resistance. *International Nickel Co.*

1509. Corrosion Resistant Alloy
20-page booklet on nickel, chromium, molybdenum, iron alloy gives chemical composition, corrosion data, properties and welding characteristics. *Haynes Stellite*

1510. Corrosion Resistant Alloy
Data sheet compares corrosion properties of Elgiloy and stainless steel. *Elgin National Watch Co.*

1511. Creep Testing
Bulletin RR-13-54 on new creep testing machine. *Riehle*

1512. Cutting Oil
Folder on sulphurized cutting fluid for a wide range of machining jobs. *Gulf Oil*

1513. Cutting Oil Chart
Selection chart for seven classes of metal in nine machining operations. *Aldridge Industrial Oils*

1514. Cutting Tools
36-page booklet analyzes and compares carbon, high speed, cast alloy and carbide tool materials. *Allegheny Ludlum*

1515. Definitions
36-page glossary of over 150 terms on cast iron. *International Nickel*

1516. Degreasing
New bulletin 953-1 on vapor degreasing, and advantages. Equipment. *Ramco Equipment*

1517. Descaling
24-page book "Handling Metallic Sodium" with special reference to sodium hydride descaling. *U.S. Ind. Chem.*

1518. Descaling
Bulletin on new machines for descaling steel sheets, plates and coils after hot rolling or heat treating. *Pangborn Corp.*

1519. Diamond Polishing
8-page booklet on metallographic polishing with diamond abrasive and its advantages over silicon carbides. *Elgin National Watch Co.*

1520. Die Castings
Booklet on small zinc die castings. For designers and engineers. *Gries Reproducer*

1521. Drawing and Forming
Booklet on functions and advantages of wax as a lubricant in metal forming operations. *S. C. Johnson & Son*

1522. Ductile Iron
4-page discussion of properties of conventional and ductile Ni-Resist irons. *International Nickel Co.*

1523. Electric Furnaces
Brochure on electric heat treating, melting, metallurgical tube, research and sintering furnaces. *Pereny Equipment*

1524. Electric Furnaces
Bulletin 441 on box-type electric furnaces diagrams and describes the furnaces and lists specifications. *Hevi Duty Electric Co.*

1525. Electric Furnaces
Catalog of electric furnaces and ovens for hardening, tempering, annealing, drawing, drying, baking, enameling. *Cooley Electric Mfg.*

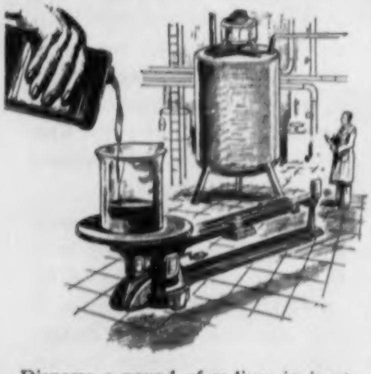
1526. Electrodeposition
12-page booklet on equipment for analysis by electrodeposition. *Fisher Scientific*

1527. Electropolisher
Bulletin on theory and practice of electrolytic polishing of metallurgical samples. Description of electropolisher. *Buehler*

1528. Extrusion Presses
8-page bulletin on aluminum extrusion presses describes the process and presses at work. *Watson-Stillman*

1529. Ferro-Alloys
32-page book tells how ferro-alloys are made and how they are used. *Electro Metallurgical Co.*

1530. Filler Metal
New colored chart gives complete line of filler metals for welding, metal each is suited to, forms available and methods with which it is used. *Arcos Corp.*



1531. Finishing Stampings
New bulletin on finishing of stamped metal parts by abrasive blasting. *Wheelabrator*

1532. Firebrick
New 28-page bulletin R-34 on properties and characteristics of 5 kinds of firebrick. Typical applications. Tables of brick quantities for arches of different sizes and shapes. *Babcock & Wilcox, Refractories Div.*

1533. Flaw Detection
Illustrated bulletin on Spotcheck, new dye-penetrant method for locating surface defects. *Magnaflux*

1534. Flaw Detection
Details about new full-color training movie on dye-penetrant methods of flaw detection. Film shows production applications, as well as explanation of the method. *Turco Products*

1535. Flow Meters
Bulletin 201 on flow meter for gas used in heat treating. *Waukee Eng'g*

1536. Forging
20-page booklet 155 on various kinds of forging hammers. Specifications, descriptions. *C. C. Bradley & Son*

1537. Forgings
Handsome 32-page brochure on large forgings for turbine shafts, rotors, drop hammer anvils, rolls. *U. S. Steel*

1538. Forgings
94-page book on die blocks and heavy-duty forgings. 20 pages of tables. *A. Finkl & Sons*

1539. Forming Dies
Bulletin No. 205 on aluminum powder reinforced epon resin casting compound for sheet metal forming dies, holding and positioning jigs and fixtures. *Metals Disintegrating*

1540. Foundry Coatings
Data on colloidal graphite for mold washes, pattern coatings, core coatings, chill coatings. *Acheson Colloids*

1541. Furnace
Bulletin on Karbo-matic furnace for carbonitriding, dry cyaniding or automatic hardening. *Pacific Scientific*

1542. Furnace Charging
12-page brochure on eight models of charging machines for heating and melting furnaces. *Salem-Brosius*

1543. Furnaces
Series of bulletins on controlled atmosphere, carburizing, nitriding, hardening furnaces. *American Gas Furnace*

1544. Furnaces
Data on luminous wall forging furnaces. *A. F. Holden*

1545. Furnaces
Bulletin on electric heat treating furnaces describes five series and accessories. *Lucifer Furnaces*

1546. Furnaces
6-page folder on gas-fired, oil-fired and electric furnaces. Typical installations. *Electric Furnace*

1547. Furnaces
Bulletin describes 18 electric furnaces for research and small-scale production, with operating temperatures to 3000° F. *Harper Electric Furnace*

1548. Furnaces
Bulletin on controlled atmosphere furnaces and generating assemblies for annealing, brazing, hardening, sintering, soldering. *Sargeant & Wilbur, Inc.*

1549. Furnaces
Folder describes complete set up for heat treatment of small tools, including draw furnace, quench tank and high temperature furnace. *Waltz Furnace*

1550. Furnaces
40-page book describes gas and electric furnaces and applications. Four basic types of atmospheres. Glossary of heat treating terms. *Westinghouse*

1551. Furnaces, Heat Treating
32-page catalog on high-speed gas furnaces for heat treating carbon and alloy steels; also pot furnaces for salt and lead hardening. *Charles A. Hones*

1552. Furnaces, Rotary Hearth
Folder giving drawings, dimensions, capacity, Btu. required for drawing, annealing, forging. *Gas Machinery*

1553. Galvanizing
Reprint "Modern Hot-Dip Galvanizing" deals with dross formation as a cause of zinc waste. *Hanson-Van Winkle-Munning*

1554. Gas Analysis
New Bulletin No. 306 on gas analysis kits for on-the-job determinations of carbon dioxide or oxygen in flue gases, furnace atmospheres and other gas mixtures. *Burrell*

1555. Gas Analyzers
Sheet 10.15-14 on applications, operation and features of thermal conductivity-type gas analyzers. *Minneapolis-Honeywell Regulator Co.*

1556. Gas Pilots
Bulletin 151-155 on specifications and instructions for manually or electrically ignited pilots. *North American Mfg.*

1557. Gear Tester
Folder gives description of tester and operating procedures. *Arch Instrument*

1558. Gear Tester
New bulletins on testing machines for roll testing of spur, worm, spiral and bevel gears. *Geo. Scherr Co.*

1559. Gold Plating
Physical, thermal, chemical, electrical, diffusion and optical properties of electroplated gold. Uses. *Technic, Inc.*

1560. Graphite Electrodes
Vest-pocket notebook containing 90 pages of information on electric furnace electrodes and other carbon products. *Great Lakes Carbon Corp.*

1561. Handling Devices
Pamphlets on clamps for lifting and handling. Their application to various industries. *Merrill Bros.*

1562. Hard Surfacing
Folder on tungsten carbide hard surfacing weld rods. *Coast Metals*

1563. Hardness Conversion
Chart comparing various testing systems and tensile strength of carbon and alloy steels. *Babcock & Wilcox Co.*

1564. Hardness Tester
Bulletin on Impressor portable hardness tester for aluminum, aluminum alloys and soft metals. *Barber-Colman*

1565. Hardness Tester
20-page book on hardness testing by Rockwell method. *Clark Instrument*

1566. Hardness Tester
New bulletin on Wolpert-Gries Micro-Reflex hardness tester for loads from 10 to 3000 g. *Gries Industries, Inc.*

1567. Hardness Tester
New 4-page folder on portable Brinell hardness tester which can be used in any position. Details of machine and its operation. *Andrew King*

1568. Hardness Testers
20-page bulletin on models, applications and how to use superficial hardness testers. *Wilson Mechanical Instrument*

1569. Heat Absorption
32-page booklet on rate of heat absorption of steel gives method for calculating heating rate. *Bloom Eng.*

1570. Heat Processing
Bulletin answers questions: what is to be heated, what sections are to be heated, why the material is to be heated, to what temperature and for how long. *Selas*

1571. Heat Resistant Alloy
10-page article on how to get best service out of standard grades of heat resisting alloys by proper selection. *Rolled Alloys*

1572. Heat Treating
Bulletin describes baskets, crates, trays, furnace parts for heat treating. *Stanwood*

1573. Heat Treating Ammonia
24-page "Guide for Use of Anhydrous Ammonia" describes heat treating and other metallurgical uses. *Nitrogen Div.*

1574. Heat Treating Belts
Catalog of conveyor belts and data for their design, application and selection. *Ashworth Bros.*

1575. Heat Treating Fixtures
24-page catalog B-8 on muffles, retorts, baskets, other fixtures for heat treating in gas or salt baths. *Rolock*

1576. Heat Treating Fixtures
12-page bulletin on wire mesh baskets for heat treating and plating. *Wiretex*

1577. Heat Treating Fixtures
Folder on carburizing boxes, trays, heat treat fixtures and baskets. *Misco*

1578. Heat Treating Furnaces
12-page booklet on various heat treating furnaces contains chronology of advances in heat treating furnaces. *Holcroft*

1579. Heat Treating Pots
Bulletin 110 gives data on sizes and shapes of cast nickel-chromium solution pots. *Fahralloy*

1580. Heating Elements
24-page Bulletin H on electric heating elements. Includes extensive tabular data on physical and electrical specifications for various sizes. *Globar Div.*

1581. High-Alloy Castings
New 16-page bulletin, No. 3354-G, gives engineering data concerning castings used for resisting high temperatures, corrosion and abrasion. *Duraloy Co.*

1582. High-Alloy Castings
Folder gives compositions and physical properties of alloys used for castings. *Coast Metals*

1583. High-Strength Bronze
12-page booklet on telnic bronze with high strength, high hardness, good machinability, age hardenability, corrosion resistance. *Chase Brass*

1584. High-Strength Steel
66-page catalog on Mayari*R steel. Applications which take advantage of its wear and corrosion resistance. *Bethlehem Steel*

1585. High-Strength Steel
48-page book on T-1 steel, its properties and applications. *U.S. Steel*

1586. High-Temperature Alloy
Property data for 21% Cr, 9% Ni heat-resistant alloy. *Electro-Alloys Div.*

1587. High-Temperature Alloys
Booklet "Keep Operating Costs Down When Temperatures Go Up." *International Nickel*

1588. Induction Furnaces
Bulletin R-31 on Ajaxomatic holding and automatic pouring unit for aluminum, copper, zinc. *Ajax Engineering*

1589. Induction Heaters
12-page bulletin on low-frequency (60-cycle) induction heating furnace for nonferrous metals. *Magnethermic*

1590. Induction Heating
12-page booklet B-6519 on equipment for induction heating for forging, hardening, annealing and metal joining. *Westinghouse Electric*

1591. Induction Heating
60-page catalog tells of reduced costs and increased speed of production on hardening, brazing, annealing, forging or melting jobs. *Ohio Crankshaft*

1592. Induction Melting
Pamphlet R-43 on twin-coil low frequency induction melting furnaces for aluminum, copper, zinc and their alloys. *Ajax Engineering*

1593. Induction Melting
16-page booklet 14-B on high-frequency converter type furnaces for induction heating and melting of ferrous and nonferrous metals. *Ajax Electrothermic*

1594. Industrial Fans
Catalogs on various kinds of industrial fans — exhaust, multiblade, backward curve for high temperatures. *Garden City Fan*

1595. Industrial Heating
20-page handbook classifies industrial ovens and gives pointers on oven selection. *Michigan Oven Co.*

1596. Instruments
Catalog 12-A-10 on instruments for indicating, recording, controlling, temperatures from —400 to +1000° *F. Fischer & Porter*

1597. Investment Casting
New bulletin on gas fired furnaces for investment casting. Also includes chart of characteristics of typical investment casting alloys. *Surface Combustion*

1598. Laboratory Furnaces
Folder describes and illustrates tubular furnace for use in tensile testing, and control panels. *Marshall Products*

1599. Laboratory Mill
4-page reprint on rolling mill for laboratory studies, which may be operated as a 2-high, 3-high or 4-high mill. *Fenn Mfg.*

1600. Laboratory Supplies
Instruments and apparatus for control, research, development laboratories. *Harshaw Scientific*

1601. Low-Alloy Steel
60-page book on high-strength low-alloy steel, properties, fabrication and uses. *U. S. Steel*

1602. Low-Temperature Properties
Article on application of extreme low temperatures to metallurgy. Behavior of metals at low temperatures. *Arthur D. Little*

1603. Lubricant
8-page folder describes use of molybdenum disulfide lubricant in cold forming, cold heading and other applications. Case histories. *Alpha Corp.*

1604. Lubricants
4-page booklet lists 44 dispersions of graphite, molybdenum disulfide, mica, vermiculite, zinc oxide and acetylene black. *Acheson Colloids*

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52-page book contains technical data and tooling information on production of aluminum parts on automatic screw machines. *Kaiser Aluminum & Chemical Sales*

1606. Magnesium
42-page booklet on wrought forms of magnesium. Includes 31 tables. *White Metal Rolling & Stamping*

1607. Magnesium Applications
60-page book gives 54 case studies on uses. *Dow Chemical*

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Booklet on how brushes are used for cleaning welds, stainless sheets, hot cast iron, automotive parts, brass fixtures. *Pittsburgh Plate Glass, Brush Div.*

1609. Melting Aluminum
Bulletin 310 on furnaces for melting aluminum. *Lindberg Eng'g*

1610. Metal Powders
Folder on a series of nickel-base alloys for hard surfacing and brazing. *Coast Metals*

1611. Microhardness Tester
Bulletin describes the Kentron microhardness tester. *Torsion Balance Co.*

1612. Microphotometer
Catalog on comparator microphotometer gives design, its operation as a recording instrument, accessories. *Jarrell-Ash Co.*

1613. Microscopes
Catalog on metallograph and several models of microscopes. *United Scientific*

1614. Monel
New booklet on engineering properties of cast Monel. *International Nickel Co.*

1615. Nickel Alloys
Wall chart gives engineering properties of nickel alloy wire, rod and strip. Includes Monel, Inconel, Incoloy and nickel-clad copper. *Alloy Metal Wire Co.*

1616. Nickel Plating
Booklet on bright nickel plating process. *United Chromium*

1617. Nondestructive Testing
8-page bulletin on equipment for nondestructive testing of bars, rods, tubing. *Magnetic Analysis*

1618. Nonflammable Rust Preventive
Bulletin on rust preventive compound which is water soluble, nontoxic and nonflammable. *Production Specialties*

1619. Optical Pyrometers
8-page catalog No. 85 on optical pyrometer for plant and laboratory. *Pyrometer Instrument*

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New Bulletin 10-S on cabinet ovens describes those for use with gas, electric and steam heat for temperatures to 600° *F. Young Brothers*

1621. Ovens
16-page bulletin No. 53 on various types of core and mold ovens, special ovens and heat treating furnaces. *Carl-Mayer*

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New booklet on surface rolled patterns on steel. *Sharon Steel*

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16-page Bulletin D-104 on theory, applications and equipment for phase contrast microscopy. *Bausch & Lomb*

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1625. Photomicrography
Folder on universal photomicrographic camera describes appliance and its uses, and accessories. *Brinkman Instruments*

1626. Pickling Baskets
Data on baskets for degreasing, pickling, anodizing and plating. *Jelliff*

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12-page book on alloy selection and design for precision casting. *Arwood Precision Casting*

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8-page bulletin on investment castings of various ferrous and nonferrous alloys. *Engineered Precision Casting*

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New bulletin, F-7259, on service tips for pyrometer users tells what to do in specific instances where they are not performing accurately. *Wheelco Instruments*

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4-page booklet on infrared radiation pyrometers. *Servo Corp.*

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New catalog No. 170 on optical, radiation, surface, immersion, indicating pyrometers. *Pyrometer Instrument Co.*

1640. Quench Agitation
Information on mixers and agitators, including units applicable to industrial quenching equipment. *Mixing Equipment*

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New bulletin No. 11 on quenching oil also discusses advantages of quench agitation. *Sun Oil Co.*

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64-page book tells what happens when steel is heated and cooled, describes quenching media, quenching practices, interrupted quenching and cooling methods. *E. F. Houghton*

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Catalog 9301 on four types of radiation detectors for measuring temperatures from 125 to 7000° F. *Minneapolis-Honeywell*

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22-page book on radioisotope reagents, how they are used in research. Lists 130 organic and inorganic radioisotopes. *General Chemical Div., Allied Chemical and Dye Corp.*

1645. Radiography
Bulletins JR and AR on one and two million volt X-ray generator. *High Voltage Engineering Corp.*

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17-page bulletin on materials and accessories for radiography. Density curves for four types of films. *X-Ray Div., Eastman Kodak*

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Bulletin on continuous-type recirculating furnace shows design of furnace, its operation and advantages. *Industrial Heating Equipment Co.*

1648. Refractories
40-page book lists super-refractories for heat treating furnaces and gives data on use in different kinds of furnaces. *Refractories Div., Carborundum*

1649. Refractories
4-page bulletin on properties and applications of corundum-base refractory. *Chas. Taylor Sons*

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12-page brochure on products for casting special refractory shapes and for gunning and troweling applications, for services to 3000° F. *Johns-Manville*

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24-page booklet on how refractory grain is produced. Chemical and physical characteristics, sizes available, *Norton*

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24-page Bulletin 1053 o forming and producing sha rous and nonferrous metals. *Products Co.*

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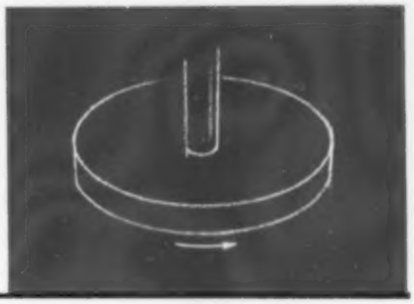

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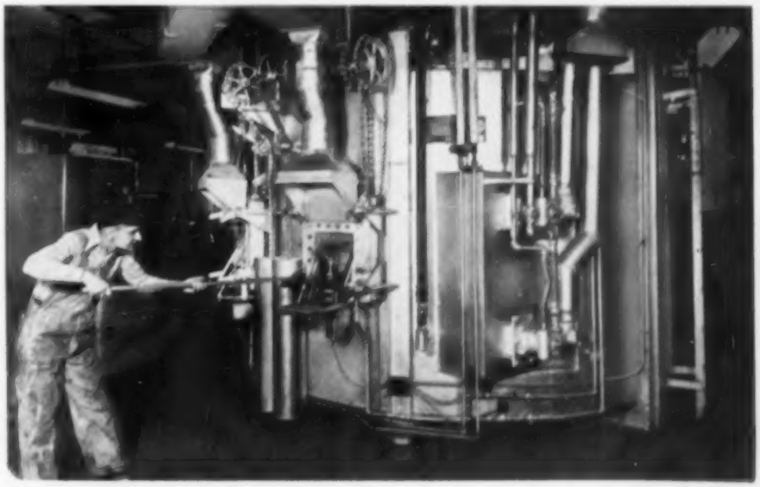

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1665. Steel 52100
Data sheet on high-purity 52100 steel, made by vacuum melting. *Vacuum Metals*

1666. Steel 52100
New stock list on 52100 tubing, bars and ring forgings. *Peterson Steels*

1667. Steelmaking
Beautifully illustrated brochure on steelmaking, annealing, hot rolling, finishing. *Rotary Electric Steel*

1668. Straightening Machines
16-page bulletin on shape straighteners, stretcher levelers; how shape straightening works. *Continental Foundry & Machine*

1669. Stress-Strain Recorders
New 28-page bulletin No. 4215 on 16 standard recorders and 50 models of strain followers, for use on standard testing machines. *Baldwin-Lima-Hamilton*

1670. Sulphur Determination
Literature on 3-min. determinator for use with combustion furnace. *Dietert*

1671. Surface Temperature
Bulletin No. 4257 on Pyrocon, surface temperature instrument. *Illinois Testing Laboratories*

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Bulletin 1E-11 on tempering and other applications in liquid baths. *Kemp*

1673. Tempilstiks
"Basic Guide to Ferrous Metallurgy", a plastic laminated wall chart in color. *Claud S. Gordon*

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4-page booklet on controlled humidity chamber gives specifications. *Blue M Electric*

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Data on machine for cutting test specimens to ASTM specifications. *Sieburg Industries*

1676. Testing Machines
Bulletin on Brinell hardness, ductility, compression, tensile, universal, transverse, hydrostatic proving instruments. *Steel City Testing Machines*

1677. Thermocouples
20-page Bulletin 714 on thermocouples, protecting tubes and wells, insulators, leads, connectors, heads. *Gen. Electric*

1678. Thermocouples
Sheet 57 on two-wire thermocouples gives specifications. *Minneapolis-Honeywell Regulator*

1679. Titanium
8-page book on producing, forming, corrosion resistance of titanium. Health and safety precautions in handling titanium. *Pigments Dept., E. I. Du Pont*

1680. Titanium Alloy
Data on ternary alloy with 3% aluminum and 5% chromium gives physical properties, forging temperatures, high temperature characteristics. *Mallory-Sharon Titanium*

1681. Titanium and Zirconium
16-page bulletin, "The Hydrimet Process", on titanium and zirconium metals and hydrides, and other metallurgical hydrides. *Metal Hydrides*

1682. Tool Steel
New 44-page book on tool steels for the nonmetallurgist explains the six basic kinds of tool steels and their heat treatment. *Crucible Steel*

1683. Tool Steel Guide
New 70-page brochure includes information on 50 types of tool steels and cold finishing products. *Vanadium-Alloys Steel Co.*

1684. Tools
New 64-page catalog of rotary burrs, grinding points, saws, testers and other metalworking equipment. *Martindale Electric*

1685. Tubing
52-page "Handbook of Seamless Steel Tubing". 26 pages of data. *Timken*

1686. Tubing
Bulletin on small tubing of stainless, nickel and nickel alloys. *J. Bishop & Co. Platinum Works*

1687. Tubing
Bulletin on applications of cold drawn Electricweld tubing. *Jones & Laughlin Steel Corp.*

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12-page bulletin DH-114 on Tukon micro and macro hardness testers. *Wilson Mech. Inst.*

1689. Tungsten Alloy
20-page booklet on machinable tungsten-copper-nickel alloy lists properties, manufacturing and finishing. *Fansteel Metallurgical Corp.*

1690. Vacuum Furnaces
New vacuum furnace bulletin. *National Research Corp.*

1691. Vacuum Melting
8-page bulletin on production and testing equipment for vacuum melting. Advantage. *Utica Metals Div., Utica Drop Forge & Tool*

1692. Vacuum Metallizing
Reprint "High Vacuum Metallizing of Metals and Plastics". *Consolidated Vacuum Corp.*

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21-page report on vacuum melted metals discusses equipment, properties of metals and their applications. *Ajax Electrothermic Corp.*

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New Bulletin 377 on vacuum oven discusses special features. *Precision Scientific*

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New 8-page booklet 756 on diffusion and booster pumps for high vacuum processing. *F. J. Stokes Machine*

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189-page book on properties of ferrous alloys containing vanadium and their applications. *Vanadium Corp.*

1697. Waste Treatment
16-page booklet on instrumentation for control of cyanide and chrome waste treatment processes. *Fischer & Porter*

1698. Welding Equipment
Catalog on Cadweld process and arc-welding accessories. *Erico Products*

1699. Welding Magnesium
Article on inert-gas-shielded metal-arc welding of magnesium includes numerous illustrations and tables of data. *Dow Chemical*

1700. Welding Stainless
8-page Bulletin GET-1955 gives arc-welding practices for stainless steels. *General Electric*

1701. Wire Mesh Belts
130-page manual on conveyor design, belt specifications, metallurgical data. *Cambridge Wire Cloth*

1702. X-Ray Diffraction
Bulletin 8A-3505 on film or direct recording X-ray diffraction apparatus. *X-Ray Div., General Electric*

1703. Zinc and Cadmium Plate
Technical data sheets on use of Lusteron salts for zinc and cadmium plating. *Chemical Corp.*

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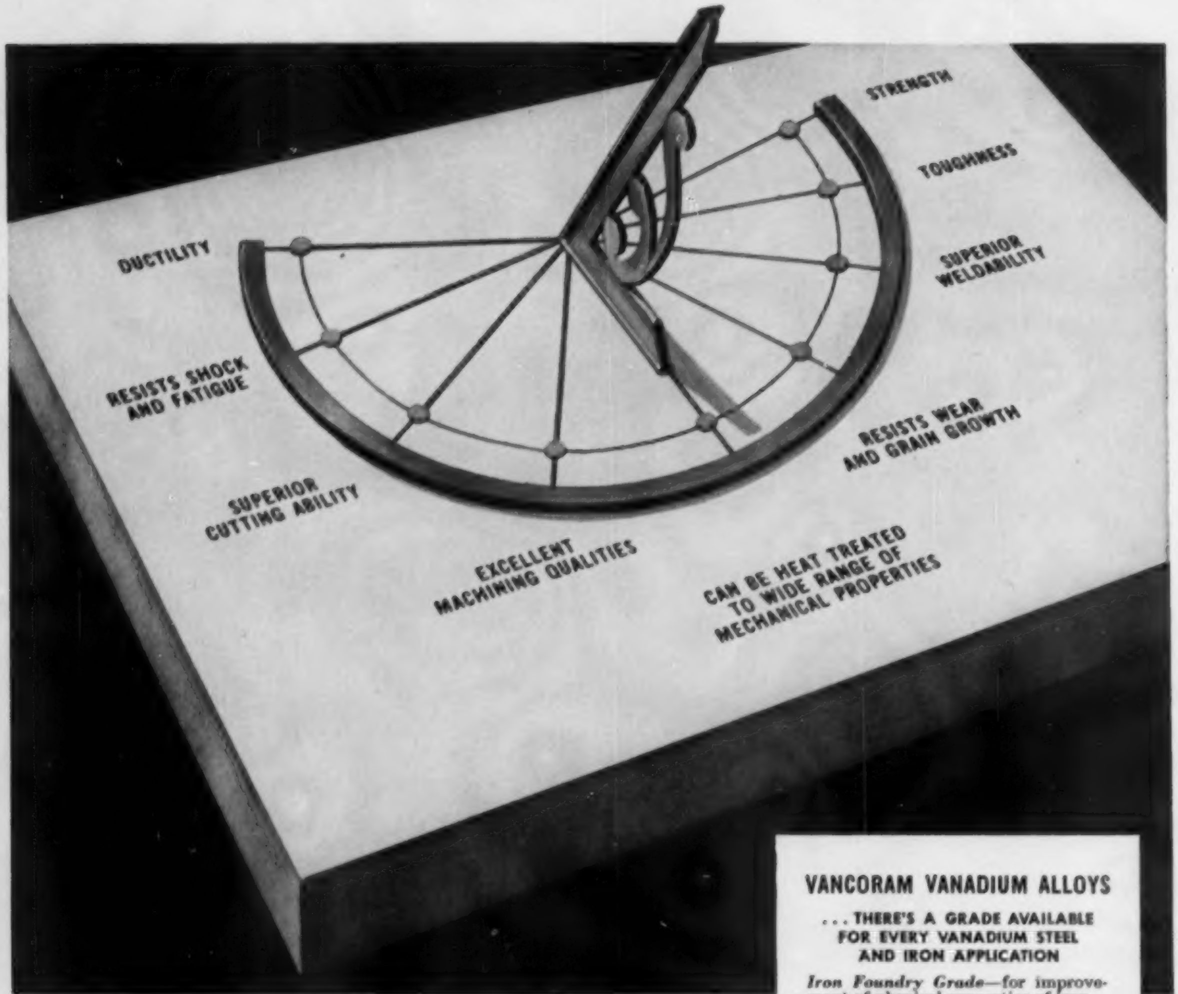

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... THERE'S A GRADE AVAILABLE FOR EVERY VANADIUM STEEL AND IRON APPLICATION

Iron Foundry Grade—for improvement of physical properties of iron.
Grade A (Open Hearth)—for low vanadium steels and vanadium cast irons.
Grade B (Crucible)—for tool steels and other high-vanadium steels requiring a limited silicon addition.
Grade C (Primos)—for making the highest vanadium and the lowest silicon addition to tool steels.
Vanadium Metal (90% grade)—for special iron-free (nonferrous) or low-iron alloys, or for low impurity ferrous alloys.
Vanadium Pentoxide, Tech.—a source of vanadium in basic electric-furnace steels. A base for numerous chemical compounds.

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420 Lexington Avenue, New York 17, N. Y.
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Producers of alloys, metals and chemicals


2


3


4


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7

"Economical Buying of Screw Machine Products Now Calls for Greater Care in Specifications,"

says Leonard Schaffer, President, Mechanical Art Works, Inc., Newark, New Jersey

A few typical fine-finish, close tolerance screw machine products currently produced from ANACONDA Rods at the Mechanical Art Works.

"The tremendous versatility of automation in modern manufacturing has placed a bigger burden on the designer and buyer of screw machine parts," Mr. Schaffer explains. "The trend toward miniaturization has shifted many more parts to the screw machine. And the screw machine's ability to provide *tolerances* as close as .0005", and finishes heretofore obtainable only by centerless grinding, has left a tremendously wide choice in specifications."

Mr. Schaffer, a long-time user of Anaconda products, says, "I can count on the uniform machining characteristics of ANACONDA Rods from batch to batch, which is important for both quality and economy in my business."

For complete data on composition and machinability of standard ANACONDA Alloys, standard specifications, weights and dimensions of standard rods, write for Publication B-14. Address: The American Brass Company, Waterbury 20, Conn. In Canada: Anaconda American Brass Ltd., New Toronto, Ont. 5583

A few of Mr. Schaffer's suggestions to buyers of screw machine products for keeping costs down.

Wherever possible, the largest diameter of the piece should correspond to a standard stock rod diameter.

Avoid fancy shapes calling for expensive forming tools.

Use hole diameters obtainable with standard tools.

Allow commercial tolerances if possible, otherwise specify tolerances no closer than necessary.

Specify Standard National Coarse or National Fine Threads wherever possible.

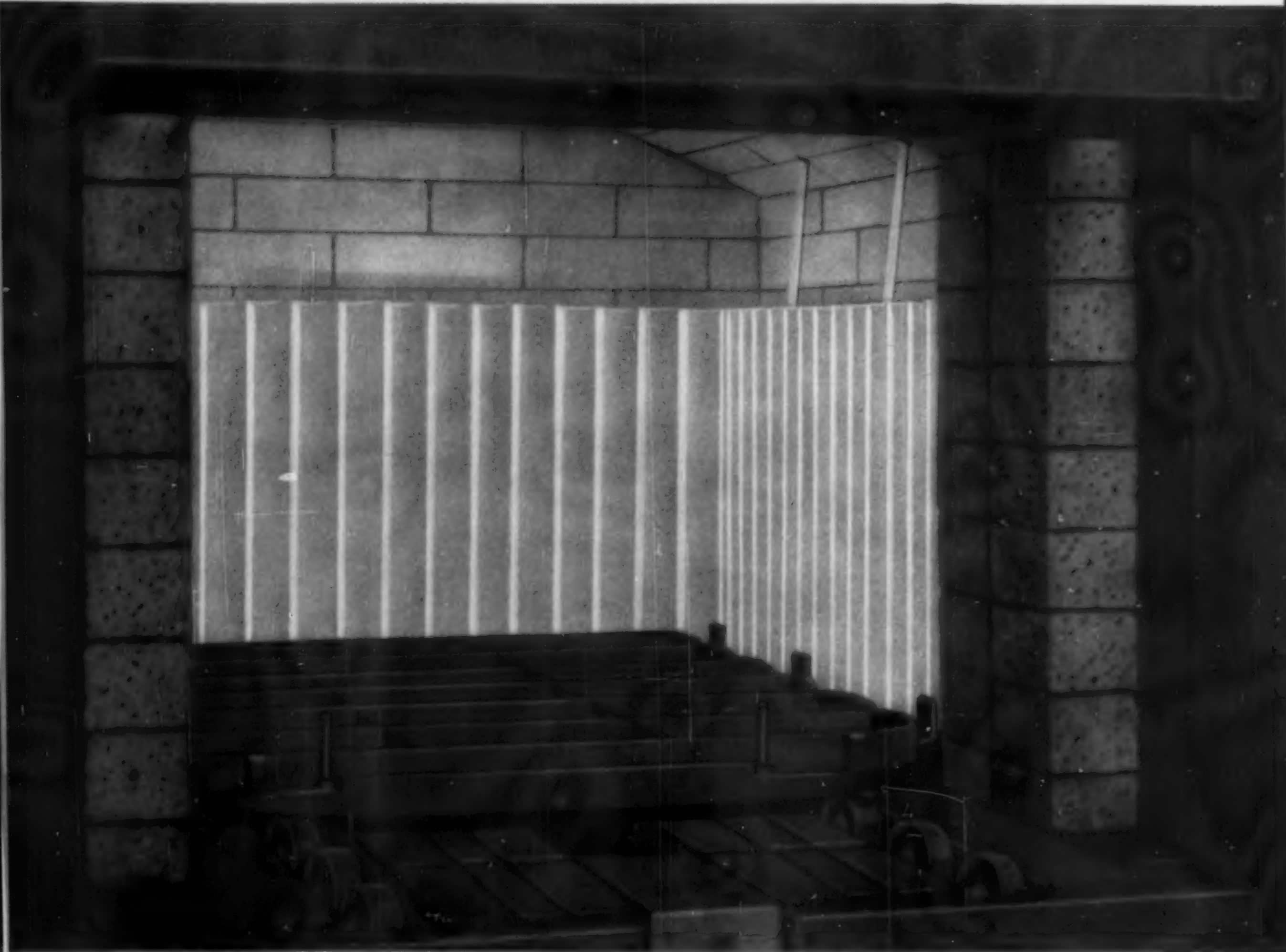
On external threads, cutting full threads close to a shoulder is expensive —and may be unnecessary.

Tapping blind holes close to the bottom is difficult and costly.

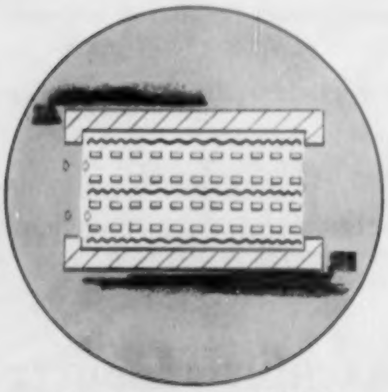
Specify free cutting material unless special physical properties are required, then select the best machining material containing those properties.

ANACONDA® RODS FOR SCREW MACHINE PRODUCTS

BRAND NEW—MODERN ELECTRIC ELEMENT

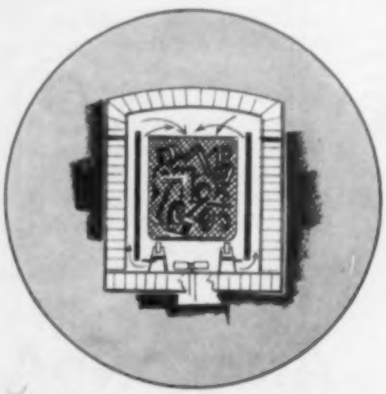


This shows graphically how the new Lindberg CORRTHERM electric heating element actually fills the furnace with walls of glowing heat. Note also that CORRTHERM is conveniently hung from simple brackets requiring no complicated connections or construction. This element operates at extremely low voltage, eliminating shock or short hazards.



In continuous type furnaces CORRTHERM elements hang between lines of work as well as on side walls. Note how closer corrugations (at each end of element) compensate for incoming cold work and door losses.

CORRTHERM elements act as natural baffles to direct forced convection streams through the charge. The use of electric furnaces for carburizing and carbonitriding now becomes completely practical.



No retort needed in pit-type carburizing furnace with CORRTHERM elements. Again see how elements serve as baffles to direct forced convection stream through charge.

FOR LINDBERG FURNACES

Never before has there been an electric heating element like this CORRTHERM by Lindberg. Its revolutionary advantages now make the use of electricity as the source of heat, practical, efficient and economical for all heat treating processes.

Ideal for use in any electric heat treating furnace, CORRTHERM elements have particular advantages for carburizing and carbonitriding. This new element completely eliminates problems formerly created by the use of electricity in these types of furnaces. These exclusive advantages of CORRTHERM explain how and why:

LOW VOLTAGE: Operates at extremely low voltage. No leakage through carbon saturation. Around Lindberg we talk about it as the electric element "without any electricity . . . to speak of!"

ATMOSPHERE CIRCULATION: Elements act as baffles to direct circulation of convection streams.

SAFETY: Extremely low voltage also eliminates shock or short hazards.

DURABILITY: Watts density at all-time low. Element practically indestructible. Work load or operator's charging tool can't hurt it.

EASILY INSTALLED: Element is not enclosed, just hangs in furnace. No complicated mountings required.

If electricity is the preferable source of heat for your metal treating processes find out how advantageously CORRTHERM elements can be applied to your requirements. Just get in touch with your nearest Lindberg Field Representative. (Consult your classified phone book.)

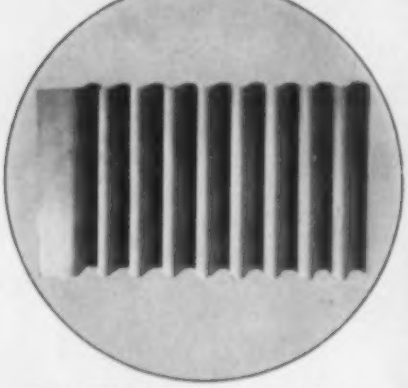
LINDBERG

LINDBERG ENGINEERING COMPANY

2448 West Hubbard Street, Chicago 12, Illinois

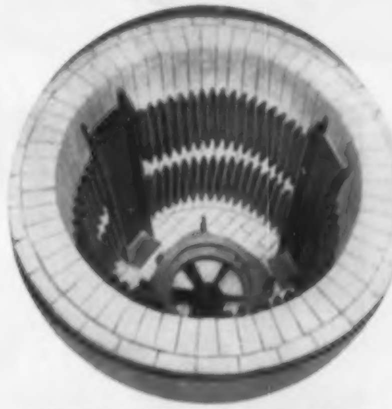
Los Angeles Plant: 11937 South Regentview Avenue, at Downey, California

Associate Companies: Lindberg Industrial Corporation, Chicago • EFCO-Lindberg, Ltd., Montreal, Canada
Lindberg Italiana, Milan, Italy • The Electric Furnace Company, Ltd., Weybridge, Surrey, England
Etablissements Jean Aubé, Paris, France • Lindberg Industrie Ofenbau, Gross Auheim, Germany



CORRTHERM elements are large sheets of corrugated nickel chromium. They were developed in Lindberg laboratories by Lindberg metallurgists and engineers.

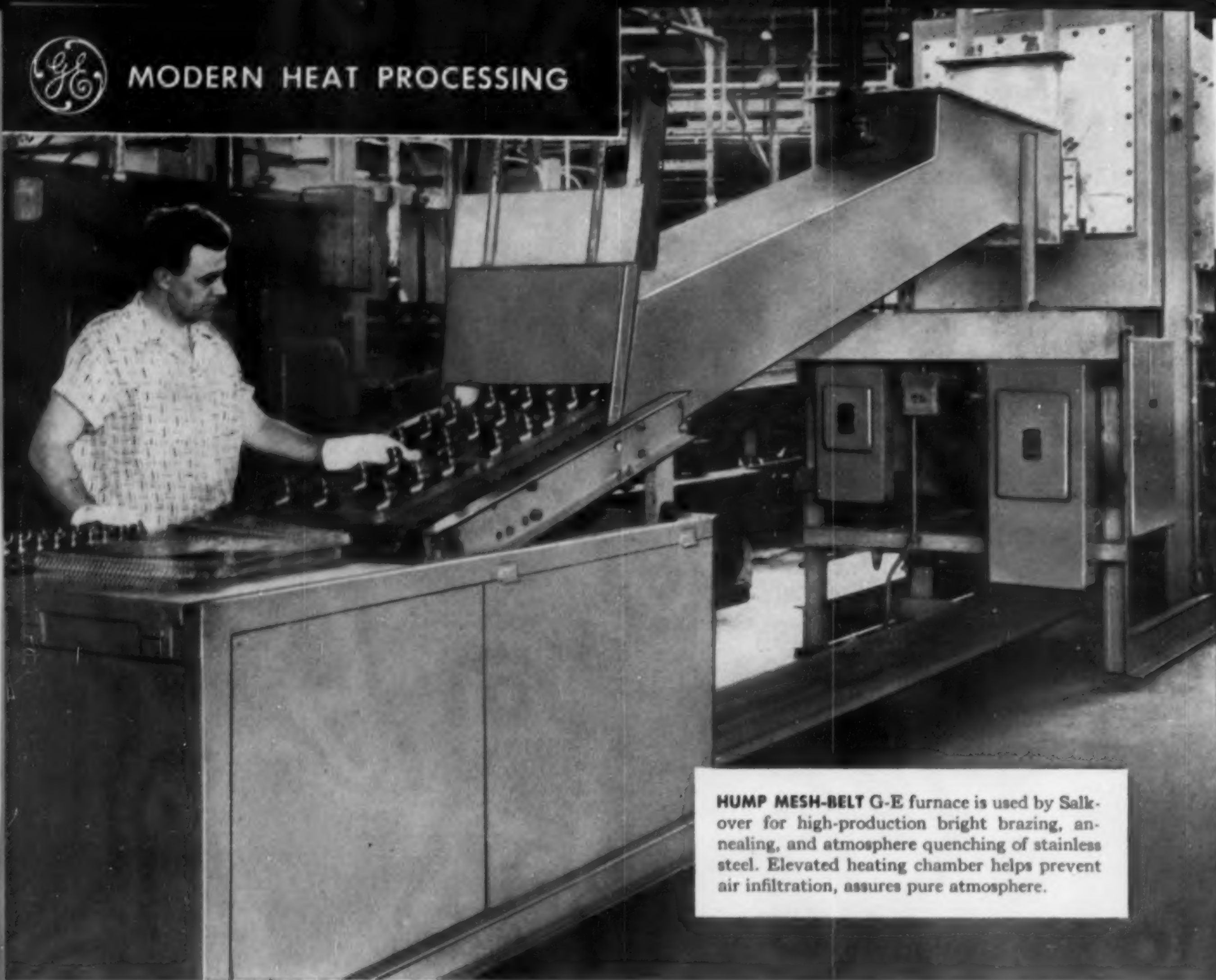
This shows installation of CORRTHERM elements in one of two large rotary furnaces currently being erected in the field by Lindberg's associate company, Lindberg Industrial Corporation.



An installation of CORRTHERM elements in a carburizing pit-type furnace. Simplicity of mounting makes replacement easy and economical.

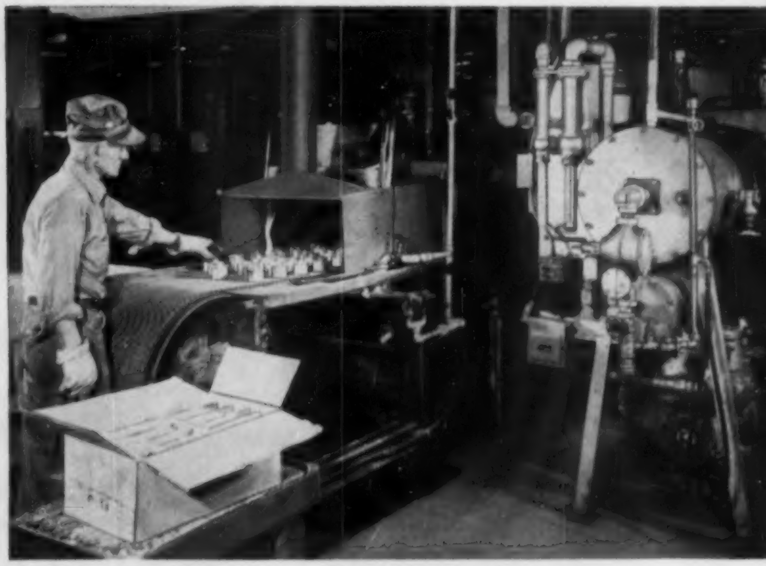
Safety! Extremely low voltage makes CORRTHERM elements completely safe. Let operator or work load bang it if they will. Neither element nor operator will be hurt.

MODERN HEAT PROCESSING



HUMP MESH-BELT G-E furnace is used by Salkover for high-production bright brazing, annealing, and atmosphere quenching of stainless steel. Elevated heating chamber helps prevent air infiltration, assures pure atmosphere.

G-E BOX-TYPE BRAZING FURNACE, is one of three used by Salkover Metal Processing for low-volume, high-quality copper brazing and annealing.



CLEAN PARTS EMERGING from Salkover's G-E mesh-belt furnaces are placed directly in shipping boxes. No need for pickling, grinding or polishing because protective atmosphere keeps parts free of scale.

PROBLEM:

How to avoid the high cost of forging and machining

SOLUTION:

Brazing with G-E Furnaces Cuts Costs 25 to 50% for Salkover Customers

Many metal-product manufacturers are constantly faced with the same problem: how to avoid the high cost of forging and machining large volumes of metal parts. More and more of these companies in the Chicago area are finding the solution: fabrication . . . and brazing with Salkover Metal Processing of Illinois, Inc.'s new G-E furnaces.

SINCE SWITCHING to G-E furnace brazing, Salkover's customers have gained savings of between 25 to 50%.

Mr. Lee Mathis, Superintendent of Salkover, explains how their G-E furnaces made these savings possible: "With our seven G-E brazing and bright-annealing furnaces I can give my customers superior quality work. The furnaces in our new, modern heat-processing plant include box, mesh-belt, and roller-hearth types. And we're sold on them for three reasons: the heating units really last, over-all maintenance is very low, and the furnaces also have high productive capacity—all pretty important for the high-volume runs our customers bring in."

THE HEATING UNITS in the General Electric furnaces have so far given Salkover up to two years' life, with no intermediate maintenance. Maintenance of other component parts and down time of the furnaces have also been low.

Also, power input is high and thermal losses low. These features permit Salkover to hold down brazing and annealing costs to customers.

ASK FOR THE SERVICES of your local G-E Apparatus Sales Representative. He will show you how the installation of a G-E furnace can help you cut processing costs and increase the quality of your product.

GENERAL ELECTRIC

VERSATILE G-E ROLLER-HEARTH furnace with return conveyor pays for itself quickly at Salkover. Performs a variety of high-production jobs—brazing, bright annealing, sintering, bright normalizing.

FREE PROCESS BULLETINS

Please send me the Modern Heat Processing and technical bulletins I have checked below.

- ☐ Protective Atmospheres, GEA-5907
- ☐ Furnace and Induction Brazing, GEA-5889
- ☐ How and Where to Use Electric-Furnace Brazing, GEA-3193C
- ☐ Mesh-Belt-Conveyor Electric Furnaces, GEA-4071A
- ☐ Electric Box Furnaces With Cooling Chamber, GEA-4066
- ☐ Roller-Hearth Electric Furnaces, GEA-4072A
- ☐ Electric Furnace Brazing, GER-106
- ☐ Furnace Brazing of Machine Parts, GER-339

Section F 721-5
General Electric Co.
Schenectady 5, N. Y.

Name ....

Company ....

Address ....

City .... State ....

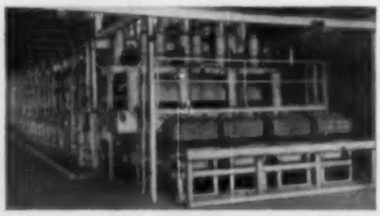
How to Select the Most Economical Insulating Firebrick

The advantages of lightweight insulating firebrick over ordinary "heavyweight" firebrick are generally known to furnace operators and furnace builders. But many buyers have wondered just what advantages there might be in one brand of insulating firebrick as against another. The answer to this question could very well mean savings in fuel costs, increased furnace output, longer life . . . or all three.

One furnace builder ran tests on their small electric kilns where heat input could be measured with great accuracy. Here's what they found: B&W IFB required 25% less heat than any other brand of insulating firebrick they tried.

The reason? B&W IFB are lighter in weight than any other insulating firebrick — they contain more tiny, insulating air cells. Heavier, denser insulating firebrick linings waste fuel two ways: They soak up and store more heat which is lost when the furnace is cooled; and they conduct more heat through the walls.

How about long life? One of the



toughest tests of firebrick is in the lining of a carbon monoxide furnace. Some brands last only a few weeks, then disintegrate, due to iron oxide impurities in the brick which react with the gas.

But B&W Insulating Firebrick contain little iron oxide, and they're processed at high temperatures so that any traces of iron oxide form stable compounds. So instead of deteriorating they stay on the job year after year —in many cases over 10 years.

Another factor, important to many furnace operators, is accurate temperature control. Here again B&W IFB have an advantage over other insulating firebrick. First, because B&W IFB are lighter in weight they store and conduct less heat—and they respond more quickly to changes in heat input.

A typical example is the giant stress-relieving furnace shown below—sixty feet by twenty-two feet by seventeen feet high. The B&W lining plays a vital part in holding the desired temperature within 5 degrees accuracy!

Next time you buy or specify insulating firebrick, remember that the lightest weight brick of all—B&W—has the highest insulation value, the longest life and the greatest furnace heat controllability.

THE BABCOCK & WILCOX CO.
Refractories Division
General Offices:
161 East 42nd St., New York 17, N. Y.
Works: Augusta, Ga.

Case No. 107

Harris Steel Co. Reports:

- 4 Years' Trouble-Free Service
- Constant 24-Hour Operation
- Careful Control of Quality

Michael J. Giordano inspects test burner on one of twin Kemp Atmos Gas Producers.

Bright Annealing Furnaces Use Kemp Atmos Gas Generators to Supply Controlled Atmosphere of Uniform High Quality

Bright annealed steel is produced by Harris Steel Company, Kearny, New Jersey, with the help of two Kemp Model 6-MR Atmos Gas Producers. These two Kemp Generators burn city gas, to supply twelve furnace bases with purified controlled atmosphere.

Treating gas 24 hours a day, seven days a week, each Kemp unit produces 6,000 cfh of gas . . . enough to meet the needs of annealing 4,000 to 5,000 tons of steel per month.

User Reports Complete Satisfaction

Mr. Harry Vane, Plant Superintendent, reports "These Kemp units have been in constant service for 4 years without a bit of trouble. The only maintenance needed has been ordinary routine. Because of the constant purity and qualitative analysis of the gas the Kemp Generators produce, we have been able to secure constant control of color, temper and quality of our output."

Kemp Can Help You, Too

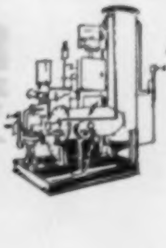
If efficient, carefully-controlled supply of protective atmosphere gas can help you solve production problems, it will pay you to call in a Kemp Engineer for a detailed discussion of your needs. No obligation, of course.

Write to: C. M. KEMP MFG. CO.,
405 E. Oliver Street, Baltimore 2, Maryland.

General view of Harris Steel Co. Bright Annealing Department, showing several of the 12 annealing furnaces supplied with Atmos Gas by Kemp Model 6-MR Generators.

This Kemp industrial carbureter—the heart of every Kemp installation—assures the desired analysis of protective atmosphere gas under any demand without waste . . . without frequent adjustments.

KEMP OF BALTIMORE



ATMOS GAS GENERATORS

ADSORPTIVE DRYERS • SINGEING EQUIPMENT
IMMERSION MELTING POTS
CARBURETORS • BURNERS • FIRE CHECKS

For reliable, economical

***Pyr-O-Vane* Controllers**

Horizontal-case model fits standard 19" relay racks. Available in a choice of control actions, including three-zone control with neutral zone adjustable from 0 to 100%, or 0 to 10%. Pre-wired panel permits checking of thermocouple or millivoltmeter without disconnecting wiring.

Vertical-case model can be flush or surface mounted.

Both types are available with "snap action" electronic vane control; on-off, two-position and three-position; and with pulse-type time-proportioning control. They are designed for fail-safe operation, and are virtually unaffected by changes in line voltage, humidity and temperature. Supplied with either thermocouple or *Radiamatic*® calibrations.

Bulletin Board

BASKETS

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for de-greasing — pickling
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materials handling
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of any size and shape —
any ductile metal

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THE C. O.

JELLIFF MFG. CORP.

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WELDCO

FABRICATED MONEL PICKLING EQUIPMENT

- Hairpin Hooks • Sheet Crates
- Steam Jets • Chain
- Mechanical Bar, Tube and Coil Picklers

THE YOUNGSTOWN WELDING & ENGINEERING CO.

3721 OAKWOOD AVE. . . . YOUNGSTOWN, OHIO

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CALL WIRETEX for WIRE BASKETS and FIXTURES

Here at WIRETEX we have the most Modern equipment and facilities for fabricating baskets and fixtures for all your plating and heat treating requirements—to resist acid, heat, abrasion or exposure in every weave, metal and alloy.

Test our Service, Quality and Price by sending us a Sample Order.

Literature available — no obligation!

Wiretex mfg. co.

[illegible] St., Bridgeport [illegible], Conn.

Specialists in Processing Carriers Since 1932.

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NOW!

foolproof bond for any product finish

DU-LITE'S PHOSPRAY

a cold spray bonding solution applied with ordinary spray equipment.

SAVES EXCESSIVE HANDLING TIME REQUIRED BY HEATED PHOSPHATE PROCESSES.

Phospray minimizes cleaning and eliminates rinsing and drying.

Phospray dries "dust free" immediately, ready for application of final finish.

Phospray can be cut with thinner as high as 3 to 1 without reducing effectiveness.

Phospray has been thoroughly field tested to govt. specs.

Phospray cuts processing time, reduces finishing costs, and provides an easy sure-fire bond for organic finishes on almost any metal.

METAL FINISHING SPECIALISTS

Phospray is made and guaranteed by Du-Lite, the metal finishing specialists.

DU-LITE CHEMICAL CORP.
MIDDLETOWN, CONN.

Send me a sample of Phospray . . . ☐
Send more Phospray information . . ☐
Have your representative call. . . . ☐

Name ____________
Company ____________
Address ____________
City ________ Zone ____ State ________

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METAL FINISHING SPECIALISTS

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7301 Euclid Avenue, Cleveland 3, Ohio

Please send further information, as checked at the right, on the advertisements in the Bulletin Board with numbers I have listed below—

(Bulletin Board Item Number)	Send Catalog or Engineering Data	Send Price Info	Nearest Source of Supply
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TO CHANGE THE Style
CHANGE THE STEEL
SWITCH TO Sharonart
Sharon
Automotive designers are finding Sharonart — the steel with a rolled in design — provides a whole new field of design possibilities. It permits re-styling without expensive die change. It provides the widest possible flexibility in working out new models. It is unusually adaptable to two-tone spray painting. It adds a richness to your product, and, because it doesn't mark or show scratches, it brings extra utility to those parts that must withstand abuse.
If you are not already familiar with the many advantages of designing with Sharonart you will want a copy of the new bulletin that thoroughly explains this remarkable steel. It's free for the asking. Contact the Sharon representative in your area or write direct.
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DISTRICT SALES OFFICES
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SHARONSTEEL
SHARON STEEL CORPORATION MP-1155
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Please send "SHARONART surface rolled patterns" in steel.
Name
Position
Company
City Zone State

PRODUCT:
Brazed joints on aircraft engine intake lines

MATERIAL:
Stainless Steel
.090 Tubing, 2.57 in. diameter, flange .120

EQUIPMENT:
250 k. v. X-ray Machine

What's the right X-ray film?

✓ Kodak Industrial X-ray Film, Type M

Heat and vibration give a tough time to the brazed joints on intake lines of aircraft engines. So for the safety of airmen and planes, each joint is radiographed.

For the x-ray job, the radiographer uses 200 k.v. for 1 min. at 60 in., a filter cassette and Kodak Industrial X-ray Film, Type M.

This type film provides the best characteristics to meet this particular combination of radiographic factors.

RADIOGRAPHY...
another important example of photography at work

THERE'S A RIGHT FILM FOR EVERY PROBLEM

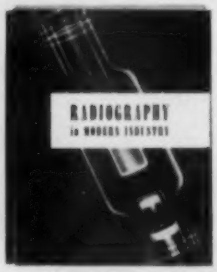
Whatever your radiographic problem, you'll find the best means of solving it in one of Kodak's four types of industrial x-ray film. This choice provides the means to check castings and welds efficiently, offers optimum results with varying alloys, thicknesses and radiographic sources.

Type M—provides maximum radiographic sensitivity with direct exposure or lead-foil screens. It has extra-fine grain and, though speed is less than Type A, it is adequate for light alloys at average kilovoltages and for much million- and multi-million-volt work.

Type A—has high contrast and fine graininess with adequate speed for study of light alloys at low voltage—heavy parts at intermediate and high voltages. Used direct or with lead-foil screens.

Type F—provides the highest available speed and contrast when exposed with calcium tungstate intensifying screens. Has wide latitude with either x-rays or gamma rays when exposed directly or with lead screens.

Type K—has medium contrast with high speed. Designed for gamma ray and x-ray work where highest possible speed is needed at available kilovoltage without use of calcium tungstate screens.



RADIOGRAPHY IN MODERN INDUSTRY

A wealth of invaluable data on radiographic principles, practice, and technics. Profusely illustrated with photographs, colorful drawings, diagrams, and charts. Get a copy from your local x-ray dealer—price, $3.

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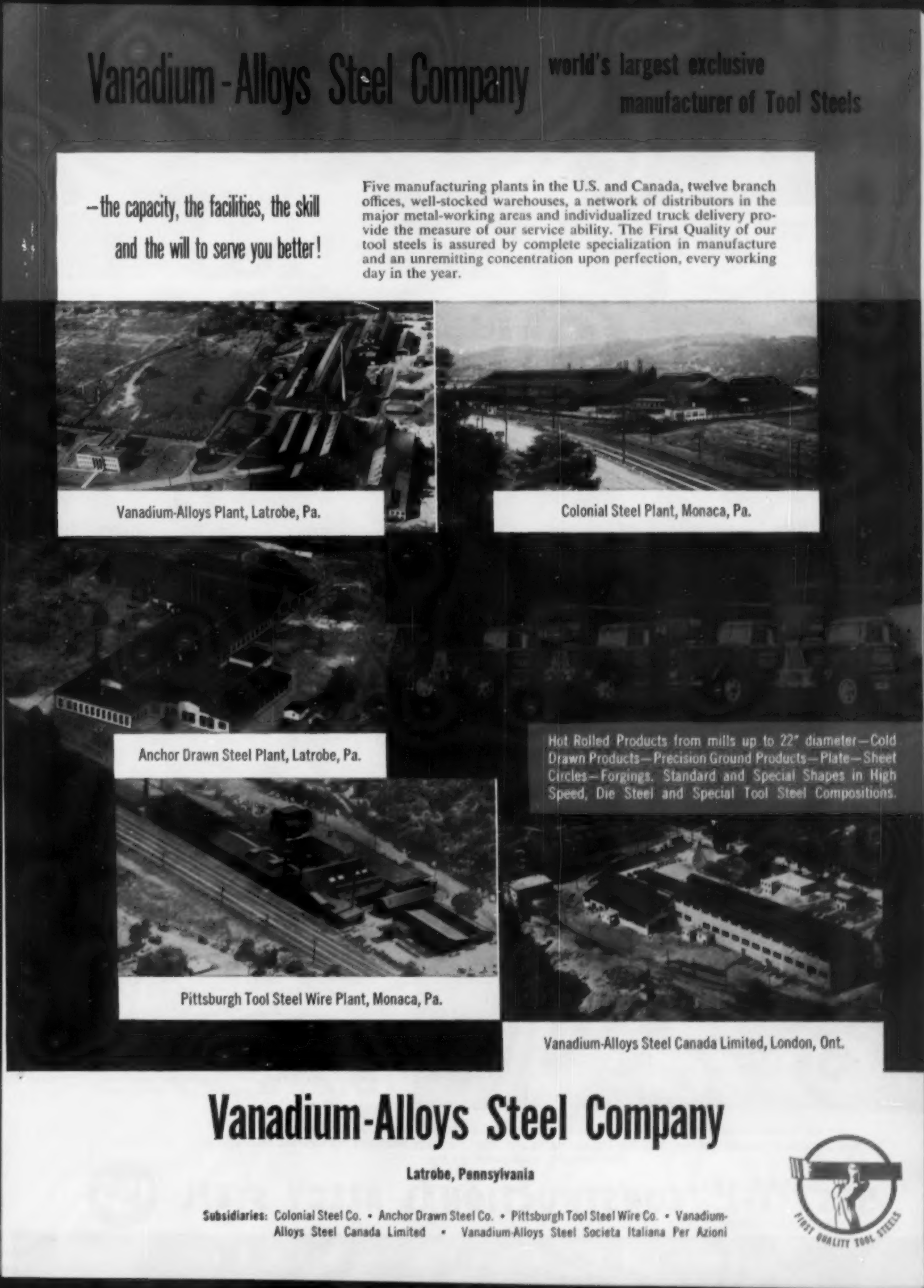
X-ray Division
Rochester 4, N.Y.

Kodak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world's largest exclusive manufacturer of Tool Steels
—the capacity, the facilities, the skill and the will to serve you better!
Five manufacturing plants in the U.S. and Canada, twelve branch offices, well-stocked warehouses, a network of distributors in the major metal-working areas and individualized truck delivery provide the measure of our service ability. The First Quality of our tool steels is assured by complete specialization in manufacture and an unremitting concentration upon perfection, every working day in the year.
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FIRST QUALITY TOOL STEELS

The SPEED QUEEN Story...

Carburizing Production Increased with

Park KASE 5-C*

PROBLEM Speed Queen Corp. of Ripon, Wisconsin, planned a 400% increase in the production of Speed Queen Automatic Washers.

More capacity, more production—about 4 times that of before World War II—was the basic problem facing the heat treat department. Most of this increase must be in carburized parts.

Problem two was extremely limited floor space. With the existng building, only 16 x 24 feet of floor space was available for furnaces, controls and quench tanks.

PARTS 22 different washing machine parts. Steel B-1113, C-1213, SAE 1020. Case depths .010-.028" required. One typical part is a B-1113 "double end pinion". Required case depth .028". Others are toggle levers, plates, rollers, etc. Case depths desired are .010" and up. Parts shown at the right.

SOLUTION Speed Queen installed two electric liquid carburizing furnaces containing Park Kase 5-C and one tempering furnace using Park Thermo-Quench Salt. Only 64 square feet of the 224 available was required. Park Kase 5-C at 1650°F produced high quality carburized cases from .010 to .028" as required. Oil quenched parts are cased .028" in 2 hours at 1650°; .010" in 30 minutes. Water soluble Park Kase 5-C permits parts to be easily washed completely clean. Speed Queen reports a complete absence of rejects and reworks as well as much lower costs.

***Park Kase 5-C is a liquid salt bath carburizing compound. It is water soluble, combining ease of cleaning with rapid carburizing rates. PK5-C is equally effective for light case, high dragout work and long cycle, deep casing applications.**

• Liquid and Solid Carburizers • Cyanide, Neutral, and High Speed Steel Salts • Coke • Lead Pot Carbon • Charcoal • No Carb • Carbon Preventer • Quenching and Tempering Oils • Drawing Salts • Metal Cleaners • Kold-Grip Polishing Wheel Cement

Park

PARK CHEMICAL CO.
8074 Military Avenue • Detroit 4, Michigan

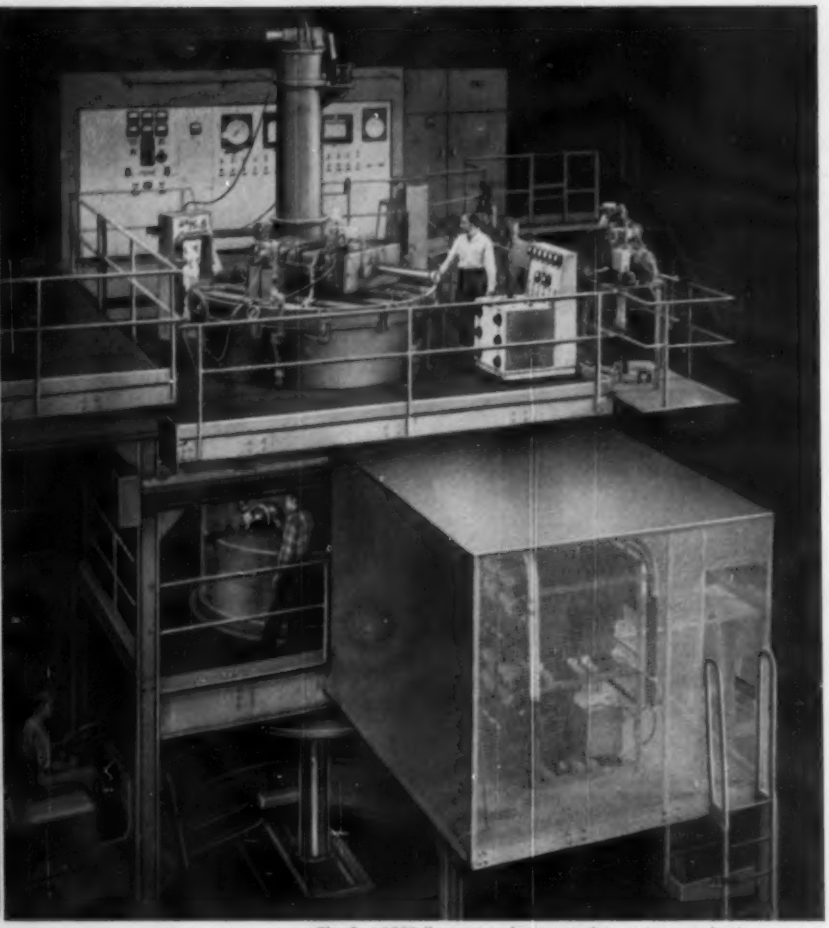
Send Free Bulletin Describing Park-Kase 5-C

Name ______ Position ______
Company ______
Address ______
City ______ State ______

Park technical lab has facilities to run samples of your products. We would be glad to suggest a solution to your problems without obligation.

Seventh in a series of advertisements describing Park processes on the Job

what made vacuum melting work?



The first 1000-lb. vacuum furnace to be put into production. Photo courtesy Universal-Cyclops Steel Corp., Bridgeville, Pa.

primarily—newly discovered vacuum techniques applied to forty years of induction furnace manufacturing experience. And only at Ajax does this experience cover so many melting developments over such a long period of time. Successful vacuum melting, as it comes from Ajax today, is just another refinement in Ajax quality melting at production speed.

The vacuum furnace illustrated above is typical of a number which are now being built for purer, stronger alloys in capacities from 5 to 2000 lbs. For details, write Ajax Electrothermic Corp., Trenton 5, New Jersey.

Associated Companies: Ajax Electric Company—Ajax Electric Furnace Co.—Ajax Engineering Corp.

AJAX NORTHRUP

SINCE 1916

INDUCTION HEATING-MELTING

WAUKESHA has the CORROSION-RESISTANT METALS to make the Quality Castings you need

to help solve your tough product design problems

SELECT FROM AMONG THESE TYPICAL WAUKESHA FOUNDRY METALS

TYPE	Description and Application
STAINLESS STEEL	
GROUP I	Martensitic—straight chromium, hardenable. Machineable. Weldable. Magnetic.
403	High stress rotating parts. Turbine blades.
410	Valve trim, oil refinery equipment, pump shafts.
416	Pinions, gears, shafts, aircraft fittings.
GROUP II	Ferritic—straight chromium, non-hardenable. Machineable. Magnetic. Corrosion resistance superior to Group I.
430	Trim work exposed to atmosphere or water. Hardware.
442, 3, 6	Scale resisting. Furnace parts, baffles, blowers, trays.
GROUP III	Austentic—chromium—nickel—non-hardenable.
302	Heat treating fixtures.
303	Food machinery equipment.
304	Dairy equipment. Magnetic traps.
305	Textile equipment.
309	Chemical equipment. Pump parts.
316	Chemical equipment. Condensers.
347	Pressure fittings.
WAUKESHA METAL	
	Copper base, high nickel content, corrosion-resisting alloy.
0	For high hardness. High tensile characteristics. Good wearing qualities.
1	Recommended for frictional parts.
3	Rather hard. Recommended for conveyor chain links, cams.
18	Recommended for use on shafts and applications involving pressure and high tensile strength.
23	Bearing alloy to be used in conjunction with stainless steel alloys for non-galling applications.
NON-FERROUS METALS	
Monel	Developed to meet requirements for specific application of corrosion resistance and bearing qualities.
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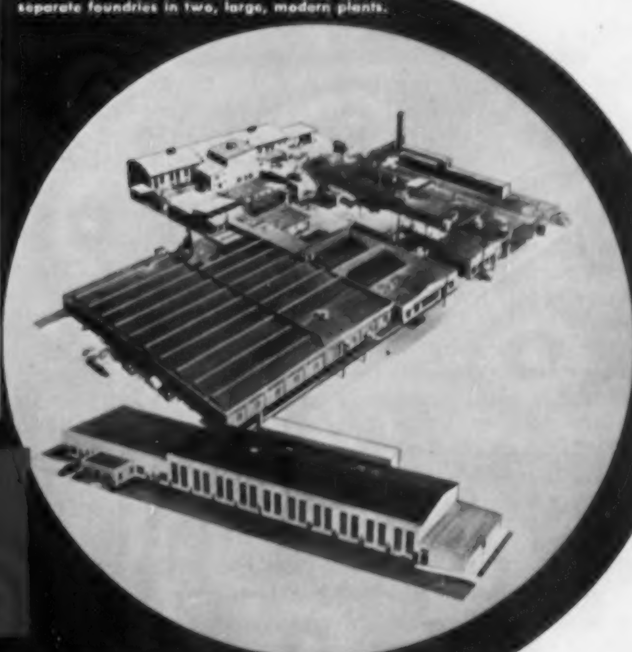

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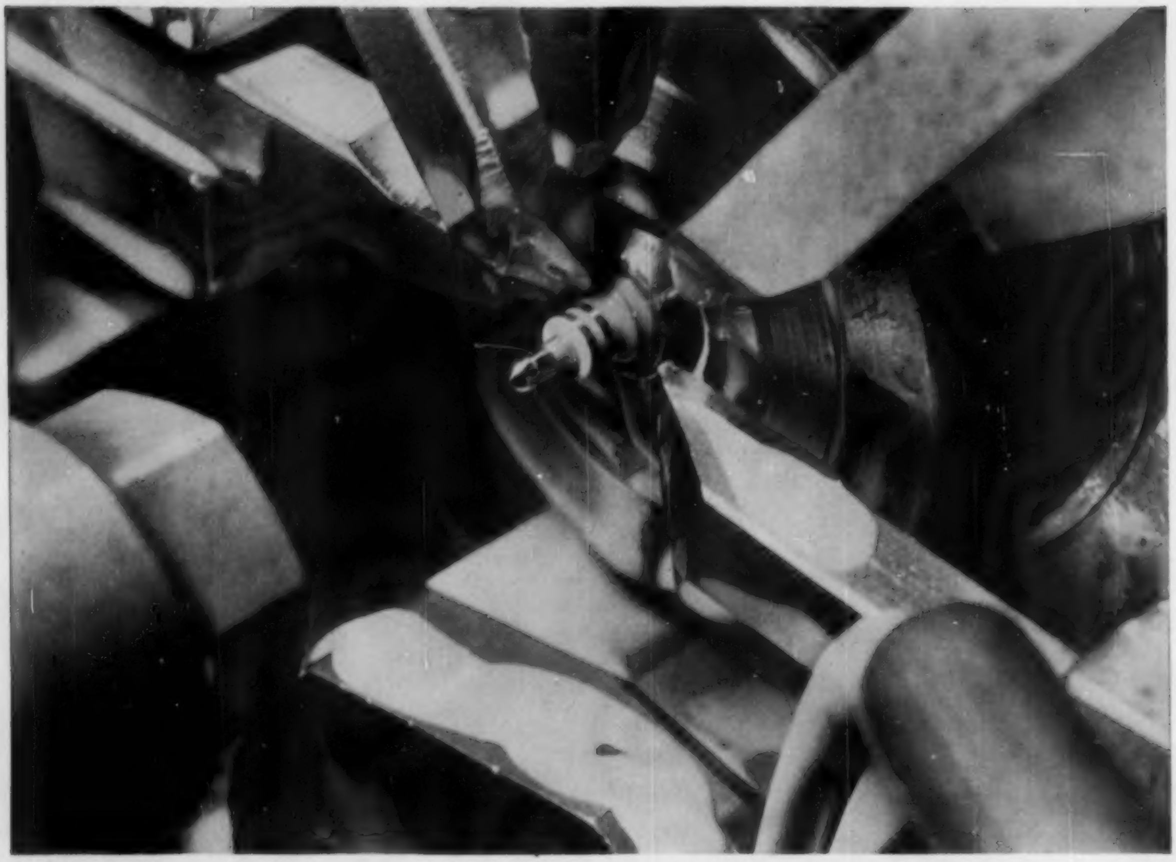

TURNING "Berylco" Beryllium Copper rod in Swiss screw machines at Molded Insulation Company, Philadelphia, Pa.

Machining "Berylco" Beryllium Copper is a run-of-the-mill operation at this plant

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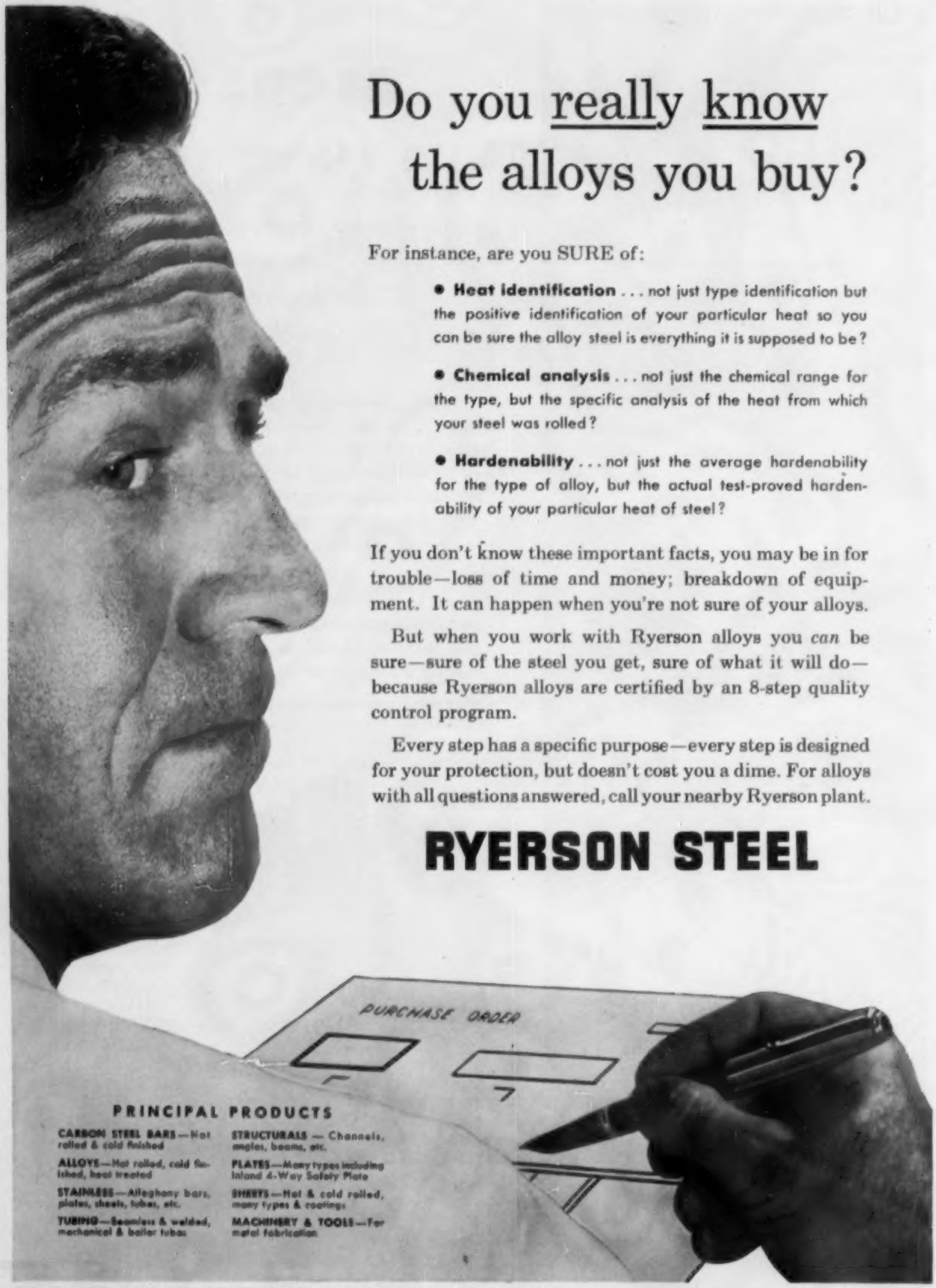
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Critical Points . . .

BY THE EDITOR . . .

Metallurgical Research and Engineering

To Schenectady, to attend some of the week-long meetings celebrating the opening of General Electric's $5,000,000 Metals and Ceramics Research Laboratory. It is seventh of a large group of buildings at The Knolls, a beautifully landscaped estate of 225 acres on a bluff overlooking the Mohawk River. Evidently research pays dividends at General Electric. The fundamental research was begun in 1900 when Willis R. Whitney started working part-time at the job. By 1945, when moving from down-town to The Knolls under the present director, C. G. Suits, a total of 630 people were employed in the central laboratories. At present the number is about 1300 (about 375 of "professional" status).

All the research work under way for General Electric at The Knolls is grouped in four divisions – chemistry, general physics, electron physics, and metallurgy and ceramics. The last mentioned division, directed by J. H. Hollomon, has 210 men and women on its roster, about half of them "professional" in ranking. In turn, this division is subdivided into six sections: chemical metallurgy (David Turnbull, manager), physical metallurgy (John C. Fisher), alloy studies (Walter R. Hibbard, Jr.), ceramic studies (Joseph E. Burke), materials and processes (Robert L. Fullman) and materials application and evaluation (Robert M. Parke). All these men, by the way, are members of A.S.M.

About a third of the ground area of the new metallurgy and ceramics building is devoted to conventional research laboratories and administrative quarters. The remaining two-thirds is occupied by a high, mill-type building, 300 ft. long, 100 ft. wide, housing a wide variety of heavy manufacturing equipment, such as a 1-ton arc furnace, a 1250-ton extrusion press, a 2500-lb. forging hammer, and a full-sized planetary rolling mill. One end of the craneway is reserved for the construction (*a la* erector set) of platforms around pilot plants, where a new manufacturing process can be tried under close observation, the bugs eliminated, cost determined, and design data accumulated.

Development of new materials and processes to a stage where they can be transferred to the company's manufacturing plants is obviously a prime responsibility of Hollomon and his men in the new metallurgy and ceramic division. In fact, it might almost be said that it is the foundation for nearly all the other work at The Knolls as well, for ideas can only be translated into electrical equipment by way of materials of some sort or other – mostly metallic.

During the week at The Knolls, much effort was expended to show that the union of metallurgy and ceramics is not a shot-gun wedding. For example, three meetings heard eleven addresses on the general topic of melting and solidification, by speakers alternately in the two fields. While undoubtedy the atomic or molecular movements during melting and freezing of matter of any sort have much in common – even of water, which was whimsically described by Bruce Chalmers as "either the hydride of oxygen or the

oxide of hydrogen freezing into a white ceramic" — the analogies seemed strained at times. Typical metals crystallize as fairly pure grains, and many alloys predominantly as solid solutions; ceramics, when they can be melted, solidify into more or less glassy objects.

A much more acceptable analogy, at least to the common or garden type of metallurgist, could have been drawn from a series of addresses comparing refractories or pottery with the products of powder metallurgy. In both of these the correct solid ingredients are usually mixed with some binder, pressed or molded to shape, and given coherence by firing at temperatures short of melting. Likewise the two arts merge one into one another when "cermets" are produced, those useful articles wherein hard or refractory compounds are cemented with a modicum of metal. Chemical combination, solution, and diffusion between aggregate and binder play important parts in the sintering operation and in the properties of the resulting artifact. Likewise only a little is known (scientifically speaking) about either — powder metallurgy because it is so young, pottery because it is so old.

Earlier in the week, General Electric played host to professors and teachers of metallurgy and ceramics from most of the American universities, wherein the educators were not only shown all about The Knolls, but also were told about activities in the plant laboratories and opportunities for graduates in manufacturing and sales in the far-flung activities of the company. G.E. not only employs a fair percentage of the specialized American educational product, year by year, but also practices its belief that educational institutions should be generously supported financially.

In the last meeting for this educational group, an equal number of industrialists interested in the supply, demand and training of metallurgists joined in a discussion of "Academic-Industrial Problems". Most of the talking was done by the teachers, and they viewed with alarm the shrinking number of young men studying metallurgy (both in numbers and in proportion to the anticipated demand) and the drain on college faculties when its members move into better-paid positions in industry. These are both old and valid complaints. Ingenious schemes were presented which might correct the situation. But is this not a small facet of a huge problem which the American nation has so far neglected? — namely, that not nearly enough money is being spent on *teachers,* all the way from college professors down (or up) through grammar school to kindergarten teachers. There are no large rewards for these essential public servants other than the intangible ones which an idealist gets from knowing he is doing a worth-while job to the best of his ability, and in our capitalistic economy these pay no butcher bills. It results that too many second-raters vegetate in the teaching profession, and do enormous damage to our cultural stature.

While more boys can be induced to go to engineering schools by campaigning among high-school students, one might cogently argue that the best way in America — maybe the only sure way — to increase the college enrollment of engineers, including metallurgists, is to increase the salaries which a really good engineer can expect to earn. When industry really gets pinched for lack of engineers it can raise salaries — not the starting salaries for fresh graduates (which now are high) but salaries for mature engineers. Few of the latter break through an \$8,000 to \$10,000 ceiling — and that's not enough in a society where coal miners get \$20 a day, carpenters \$30 and bricklayers \$40.

Engineers themselves are responsible, in part. They do not advertise. With but few exceptions,

engineers are not in the public eye. Young high schoolers are seldom attracted to engineers as leaders in their communities, men whose opinions are sought and quoted, men of outstanding reputation outside their own profession. Of course there is hardly any aspect of the American way of life which has not been vitally affected if not based fundamentally upon the work of unsung engineers, but the high schooler doesn't know that! Where is the engineer who gets, day by day, even a tiny fraction of the attention that is showered on a television star or a high-scoring athlete, a surgeon, lawyer, industrialist, salesman, banker, politician or labor leader? These men not only are in the public eye but they also drive Cadillacs.

● ● ●

Now it is obvious that the suggested solutions for the problems of low salaries and low enrollment are long-range affairs. We cannot expect that the money expended for our whole school system will be doubled overnight. We can hardly expect engineers to develop social consciousness in this generation.

The financial rewards to successful engineers on industrial staffs cannot be spectacularly increased as if by labor unions. One wonders what can be done immediately to meet the undoubted shortage, for according to Engineers Joint Council 21,500 engineers graduated in 1955 whereas American industry needed 37,000! The shortage in metallurgists is even more acute. B.S. degrees in metallurgy averaged only 550 per year for the last three years. Industry must be converting many men who studied mechanical or some other variety of engineering into metallurgists (as is indicated by educational records of members of the American Society for Metals) but this only accentuates the shortages in the other fields.

Some statistics concerning the number of young men in training as metallurgists have been collected by the A.S.M. Committee on Metallurgical Education. Two groups, one organized by Morris Cohen and the other by Cyril S. Smith, have also investigated the supply and demand for postgraduates in metallurgy. The results of such mail questionnaires must be interpreted with caution, because of ambiguities and ommissions. However, large swings should have some significance. The Editor rounds out the available figures as follows (top of page):

	All Engineering	Metallurgy	Relation
B.S. degrees, 1953 to 1955	21,500 per yr.	550 per yr.	2.5%
M. S. degrees, 1953 to 1955	4,000 per yr.	140 per yr.	3.5%
Ph.D. degrees in 1955	600	65	10.8%
Metallurgy Ph.D.'s needed for academic posts (existing vacancies)			55
Metallurgical students now in school (juniors and seniors)			1200
Graduate students in metallurgy, 1955-1956			600

These figures show one thing which is good or bad depending on whether you are interested in men for production or for research. Our metallurgical schools are training a disproportionately large number of doctors of philosophy (and four-fifths of them are in "physical" metallurgy). The teachers say that industry wants them, is willing to pay a premium as entrance salary. Likewise that a great many are needed to replace the teachers continually leaving for better-paid jobs in industry – although the danger of ingrowth and nepotism should be obvious. At any rate, the figures show that in recent years the graduate schools in metallurgy have flourished while the undergraduate body is languishing. Of the 550 bachelors in metallurgy graduated last year (engineers, it seems, are no longer produced by our engineering colleges) considerably less than 450 were available for industry. This pitifully small figure might be raised somewhat if the metallurgical faculties would try to reorient the objectives of the students they now have.

Just one more statistic: Of the universities reporting to the A.S.M. questionnaire, only 11 – all small – stick exclusively to teaching. Of the rest, the total teaching faculty is 132 men; the total research faculty is 298 – more than two researchers to one teacher. This puts some point to the query, "Are the universities running schools or are they running research laboratories?"

"Ah," but the educators say, "our sponsored research work pays salaries to our graduate students and augments the pay of our teaching staff. It is one ready means whereby industry can make financial contributions to advanced education." Even the Editor can agree to these propositions, provided the whole educational effort does not get lopsided.

Looking at the statistical record, however, it would appear that far too few metallurgical engineers are being provided for American industrial production. It is the Editor's belief that this is caused by low salaries and inefficient use of such engineers as do get into industry, and to the metallurgical faculties' penchant toward research and toward the teaching of researchers for more research rather than toward the production of embryonic engineers for industry. ●

Limitations of Steel Specifications

By E. H. SNYDER*

Steel specifications can be misleading; although they limit the range of most of the important properties, the range is often too wide or some unmentioned property can cause processing difficulties. (S 22, ST)

Few users of steel would call up a mill or warehouse and say, "Send me some steel." If one did, the vendor would immediately question him about the application and request some limitation on dimensions and mechanical properties. These limitations, which are usually set by a specification, are a compromise between the properties the user wants and the properties that the producer is able to supply consistently at a reasonable price.

Specifications can be set up to include practically any combination of properties required. The most common include limits on chemical composition, dimensional tolerances, mechanical properties and metallurgical characteristics such as grain size, hardenability and cleanliness. Other properties which can be specified include corrosion resistance, forming and welding behavior, or electrical and magnetic properties. Naturally, as the number of properties specified is increased,

*Chief Metallurgist, Austin-Western Co., Aurora, Illinois.

or the acceptable range decreased, cost will go up.

Many large organizations such as government agencies and automotive and electrical firms have created their own specifications to suit particular needs. Smaller firms rely on specifications issued by groups such as A.I.S.I., A.S.T.M. or S.A.E. These specification-issuing organizations cooperate in an effort to keep specifications simple, pertinent and consistent, and at the same time to hold required properties within limits which will permit economical fabrication and few service failures. Unfortunately, some factors such as decarburization, segregation and range of composition cannot be held within optimum limits consistently and economically. There is no point in creating specifications with desirable close limits if no producer will guarantee to deliver steel within these limits.

Many misunderstandings, processing troubles and service failures arise from a lack of understanding of the limitations of specifications. If the steel is purchased to a specification, many fabricators think that it should always behave the same way. If troubles occur, someone should be blamed – either the vendor, the workmen or the man who selected the specification. Perhaps an individual *is* at fault but usually these troubles go back to our expecting too much of specifications. Some of the more common difficulties can be traced to the fact that steel is originally cast in large ingots. There are bound to be differences in composition throughout the mass and some segregation of impurities and alloying elements. In addition, residual elements, such as copper and nickel, are always present and if they are not limited by specification can be harmful.

When structural steel or plate is purchased to a specification such as S. A. E. 1017, the mill will furnish steel with a ladle range within the composition shown in the following tabulation:

Table I – Composition of A.I.S.I. 9845 Forgings

	Analysis of Two Forgings		Ladle Range	Check Range
Carbon	0.42	0.41	0.43-0.48	0.41-0.50
Manganese	0.68	0.69	0.70-0.90	0.67-0.93
Phosphorus	0.011	—	0.040 max.	0.045 max.
Sulphur	0.020	—	0.040 max.	0.045 max.
Silicon	0.29	—	0.20-0.35	0.13-0.37
Nickel	0.79	0.80	0.85-1.15	0.80-1.20
Chromium	0.72	0.69	0.70-0.90	0.67-0.93
Molybdenum	0.22	0.22	0.20-0.30	0.18-0.32

S.A.E. 1017	Ladle Range	Check Range
Carbon	0.14 - 0.21	0.11 - 0.25
Manganese	0.30 - 0.60	0.27 - 0.63
Phosphorus	0.04 max.	0.05 max.
Sulphur	0.05 max.	0.06 max.

The check range on carbon after rolling (right-hand column) is 14 points or twice the ladle range. Steels at the extremes of this check range have very different properties–strength, ductility, formability, weldability and low-temperature toughness. Fabricating behavior and service performance can be entirely different. Other carbon and alloy steels have similar wide ranges; for example, the check ranges for 13 S.A.E. steels from 1006 to 1030 overlap the check analysis range of S.A.E. 1017.

The majority of heats of any grade of steel come reasonably close to the center of the specification range, but when a few hundred consecutive heats are considered, the extreme limits are occasionally approached. An example of several elements nearly at the bottom of their ranges is shown by some moderately heavy forgings of A.I.S.I. 9845 steel. The forgings hardened poorly when given the usual oil quench from 1550° F. Analyses of two of the forgings are given in Table I along with the specified ladle and check ranges for this steel. Carbon, manganese, nickel and chromium are each near the lowest acceptable limits, and even molybdenum is well down

Table II – Variation in Composition of Carbon Steel Plate

	C	Mn	P	S
Specification range	0.15 - 0.22	0.30 - 0.60	0.04 max.	0.05 max.
Check analysis range	0.12 - 0.26	0.27 - 0.63	0.05 max.	0.06 max.
Ladle analysis	0.17	0.55	0.010	0.035
Slug No. 3, average of thickness	0.20	0.58	—	0.072
Slug No. 6, average of thickness	0.26	0.62	0.011	0.093
Slug No. 6, halfway between surface and center	0.34	—	—	—
Slug No. 6, center of thickness	0.47	—	—	—

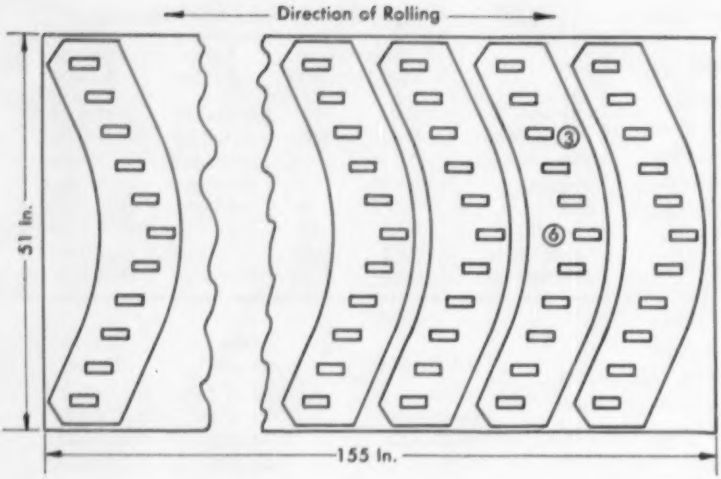


Fig. 1 – Location of Punch Slugs in Carbon Steel Plate

in the lower half of its range. If there were a standard hardenability band for 9845, this very low-alloy heat would probably fall below the bottom of the band.

For economical fabrication and greater confidence in calculated safety factors, steel with much closer limits on all properties would be desirable. By negotiation with vendors, closer limits can be obtained – at increased cost, of course. However, spreads of 0.02% or 0.03% on carbon, 0.10% on Mn and other equally close limits are almost unobtainable even at a very marked increase in cost. Some large consumers of steel test each heat and segregate it into groups suitable for particular applications. The low-carbon group, for example, may be used for a critical cold forming operation, the higher carbon group for an application requiring strength but no forming.

Segregation – When steel cools in an ingot mold, carbon and sulphur tend to segregate in the upper center part of the ingot. Rolling or forging will not eliminate the segregation, and carbon variation from surface to center will actually increase because of surface decarburization in the necessary heating operations. One example of the combined effect of segregation and decarburization is some carbon steel plates (¾×51×155 in.) which had been purchased to a chemical composition only.

Eleven 1×4-in. rectangular holes were punched at constant spacing across the width of these plates as shown in Fig. 1. Near the edge they punched easily and the punch slugs had the torn or deformed sheared surfaces characteristic of mold steel. For some plates, the difficulty of punching increased from edge to center. The center slugs broke out with a loud "bang" and had smooth sheared surfaces.

The difference in surface appearance is apparent in Fig. 2. It was difficult to hold the punching die in proper relationship to the punch. The variation in composition of slugs from one such plate is shown in Table II.

Carbon segregation caused the punching difficulty, but when samples for analysis were taken representative of the entire cross section, the only ground for rejection was high sulphur. This is rather an extreme example of segregation but when large quantities of steel are fabricated, even worse examples will occasionally be found that may cause trouble both in fabrication and in service. If the above plates had been torch-cut and welded into a structure, their abnormal composition might not have been discovered, but the high carbon and sulphur could easily lead to defective welds and failure.

The value of surface hardness was uniform across the plate, between Brinell 111 and 114, and gave no advance indication of the variation in punching behavior. The hardness in the center of the cross section was Brinell 170 near the plate edge and increased to 217 toward the center. No carbon analysis was made of the region close to the surface but the low surface hardness indicated that it may well have been below 0.12%, the lower limit of the check analysis specification.

Decarburization is present on all hot rolled steel yet few of the widely used steel specifications limit its depth. Some large consumers of steel negotiate with their suppliers for definite limits; without such limits, the supplier will

Fig. 2 – Slugs Punched From Carbon Steel Plate. Upper one has torn surfaces characteristic of mild steel; the lower has smooth surfaces characteristic of medium-carbon steel

assume no responsibility for its presence. Since it lowers surface hardness (and wear resistance and fatigue strength) it may be responsible for erratic results in heat treatment.

A representative example of the effect of decarburization is a 1-in. diameter rod whose surface hardness must be in the range of C-50 to 58. We buy 1.125-in. diameter S.A.E. 4140 and 50B50 bars and machine to 1.020 in. prior to heat treatment. Frequently a batch of heat treated parts will have low hardness values, sometimes as low as C-26 to 30. After heat treating, the bars are rough ground to 1.001 in. and finish ground to size. Hardness checks after rough grinding almost invariably show the hardness to be well within the specified C-50 to 58 range. This indicates that depth of decarburization will frequently be more than 0.05 in. but seldom over 0.06 in. for this size bar.

For similar applications some fabricators often use cold drawn bars closer in size to the required dimensions in order to eliminate some machining. Surface hardness is obtained by recarburizing. Occasionally such bars harden very poorly on the surface even in a drastic quench. The difficulty arises from the fact that in some oxidizing environments not only is carbon oxidized from the surface of the steel, but also manganese and silicon near the surface are oxidized. These elements do not form volatile oxides and if the surface layer of the steel is analyzed they are found to be present in specified quantity even though totally ineffective as alloys. The steel acts very much like a pure iron-carbon alloy with no other alloying element, and is very shallow hardening. No ordinary steel specification covers depletion of effective alloy in the surface of steel. The supplier would be expected to assume no responsibility for this occurrence in the absence of agreements covering it.

Hardenability–The development of the Jominy test and its acceptance 10 to 15 years ago as a standard measure of hardenability have been extremely helpful in controlling heat treatment. We know within much closer limits the relative depth of hardness penetration of a particular alloy if it is purchased to a hardenability specification rather than chemical composition alone. For example, S.A.E. 8640 purchased to a hardenability specification will harden to C-50 between 4/16 and 11/16 in. from the end of a Jominy bar. This means that the minimum size round bar quenched in mildly agitated oil that will be C-50 in the center is 0.8 in. in diameter and the maximum is 2.0 in. When the same alloy is purchased to composition limits only, the spread on the Jominy test specimen for C-50 is 2/16 to 15/16 in., equivalent to about 0.2 and 2.6-in. diameter rounds respectively. The more limited spread is a big help in approaching consistent hardening of heat treated parts. The range is still so wide, however, that identical parts heat treated from many consecutive heats of the same grade of steel will not always stay inside a specified hardness range of 5 to 6 Rockwell C points. Some large consumers segregate high and low-hardenability

heats of steel and channel them to applications which can use them to the best advantage. Others negotiate with their vendors for closer hardenability ranges. One of the present dangers of buying alloy steel without hardenability specifications is that the vendor will supply steel whose hardenability is either too high or too low to meet other customer specifications.

Hardenability is becoming increasingly important with carbon steels as well as with alloy steels. Induction hardening, flame hardening, and drastic quenching of shallow hardening carbon steels is increasing rapidly for "shell hardened" highly stressed parts. For successful shell hardening there must be a proper balance of section shapes and sizes, depth of hardening, and condition of unhardened core. When this balance is held within appropriate limits, gears, spline shafts and other highly stressed parts may be made which can endure high intermittent stresses without developing fatigue failures. Control of hardenability of carbon steels used for these applications is necessary to prevent quench cracking and to control distortion and depth of hardness penetration. To keep the hardenability for these applications within desired limits requires not only control of the specified elements of the carbon steel being used, but also residual alloys, grain size and microstructure.

Some large consumers of carbon steels for shell hardening have negotiated private hardenability specifications with their steel suppliers. No general specification has yet been issued to cover hardenability of carbon steel.

Seams and Surface Scratches

Other causes of erratic processing that are not included in general specifications are such things as seams and surface scratches. They can cause deep cracks during forging, cold forming or quenching and if not detected in processing may cause premature failure in service.

One manufacturer who makes millions of studs from cold drawn steel was asked if any of them ever cracked in heat treatment. "All the time," he replied. Seams were the most common cause of this cracking. Although occasional lots of steel might show a high percentage of cracking the over-all average was low, about 1%. The steel vendor agreed to accept responsibility for seams if they are over 0.001 in. deep per 1/16-in. diameter, provided this much stock is removed before subjecting the steel to any operation which might cause them to deepen. If oversize steel were purchased for making these studs and 0.001 in. turned off each side per 1/16-in. diameter, the cost would be many times that of a low percentage which must be scrapped.

Conclusion – I hope that I don't leave the impression that the only steel specifications acceptable by steel producers are so wide that they are almost meaningless and that even these specifications are subject to numerous deviations and loopholes. It is true that for many applications, if closer limits could be held for all parts of each heat of steel, fabrication would be cheaper, scrap loss lower and service failures measurably reduced. Nevertheless, these less than perfect specifications for less than perfect steel are far better than no specifications.

If there is sufficient demand for closer control and a willingness to pay for it, more nearly uniform and less troublesome steel can be obtained. The additional cost is probably justified much more frequently than advantage is taken of its availability. The reason is mainly because additional material costs show up in the records very plainly while reduced fabricating costs and reduced scrap loss show up quite indirectly and are not found unless an effort is made to uncover them. With the passage of years, there is improvement in specifications and the limits to which they are held. The development of hardenability specifications for alloy steels within the last 15 years has been a real advance. Other improvements will come if there is sufficient demand. If there is widespread complacency, improvement will be slow.

As long as steel is processed from melting furnaces through ingots, heating furnaces and rolling mills by present methods, we will continue to have a considerable degree of segregation, seams and decarburization. Nonoxidizing furnaces and processes for converting steel directly from the molten state into rolled, extruded or drawn products without passing through the ingot stage may eliminate some of the difficulty in future years.

In the meantime, fabricators should remember that steel is not a uniform foolproof material, but is subject to many imperfections and deviations from desired properties. The fact that only a small percentage deviates badly does not make it insignificant. Fabricating costs are often many times the cost of the steel used. When these costs are wasted on defective steel and the finished product must be scrapped, the loss is much more than the cost of the steel alone.

Longer Life for Chromel-Alumel Thermocouples

*By N. F. SPOONER and J. M. THOMAS**

Errors that develop in Chromel-Alumel thermocouples enclosed in long narrow protection tubes can be minimized or prevented by elimination of metallic oxides, inserting titanium as an oxygen getter, and hermetically sealing the assembly. (S 16)

THERMOCOUPLES made of Chromel-Alumel† are quite stable in clean, oxidizing atmospheres such as normal atmospheric air. However, good thermocouple practice requires the use of protection tubes in liquids, corrosive gases, or in locations where physical damage may occur due to rough handling.

A good protection tube, closed at the exposed end, would seem to guarantee maintenance of an accurate thermocouple under any set of conditions that would not destroy the tube, but unfortunately this has not always been true. The most obvious trouble that could occur, and yet one of the most common, has been residual foreign matter inside the tube which becomes corrosive when heated. The most common of these has been sulphur-bearing grease or oils. One recommended practice to eliminate this has been to "burn out" all tubes prior to use by soaking in a high-temperature furnace.

A more puzzling problem is the large error developed by a thermocouple when a protection tube that had been thoroughly "burned out" for impurities has too great a length-to-diameter ratio. The error would be a decrease in the thermal emf. of the Chromel-P (90 Ni, 10 Cr) alloy due to subsurface corrosion by selective oxidation of the chromium in the critical temperature range of approximately 1500 to 1900° F. It was attributed to diffusion of hydrogen from the furnace atmosphere through the tube wall to create alternate oxidizing and reducing conditions. This condition is believed now to be unnecessary to cause the corrosion, although diffusion of hydrogen may have occurred in some instances. Supplying enough clean air to the couple has helped. It is done simply by using a larger diameter tube, smaller insulators, removing obstructions at the cold end of the tube, or even bleeding a small air flow into the tube through a smaller tube.

Some rather simple tests have defined the basic problem as involving the preferential oxidation of chromium from Chromel-P in the low-oxygen-pressure atmosphere produced in a closely confined tube. Bright, oxide-free Chromel-P samples, 0.030 in. thick, were wrapped in pieces of oxidized nickel foil and placed in quartz tubes which were subsequently evacuated and sealed. Each tube was then heated for 48 hr. at a different temperature, with the results given in Table I. The type of oxidation is shown in Fig. 1.

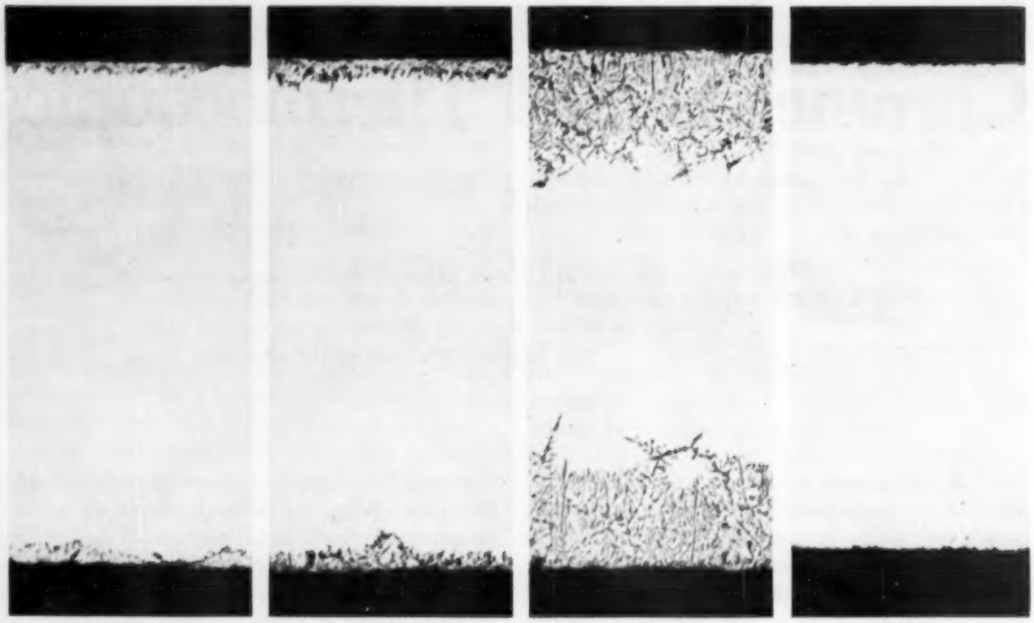
The effect is identical to that obtained with Chromel-P wire in a partially reducing atmosphere or under certain circumstances inside

*Mr. Spooner is Supervisor, Product Research, and Mr. Thomas is Manager, Metallurgical Research, Hoskins Mfg. Co., Detroit.

†"Chromel-Alumel" is a registered trade name of Hoskins Mfg. Co.

Table I – Oxygen Transfer From Oxidized Nickel to Chromel-P Alloy in Evacuated Sealed Tubes for 48 Hr.

Exposure Temperature	Weight Loss of Nickel	Weight Gain of Chromel-P	Intergranular Penetration
1620° F.	0.009 g.	0.006 g.	0.001 in.
1720	0.015	0.012	0.002
1820	0.033	0.031	0.008
1920	0.006	0.003	Nil



1620° F. *1720° F* *1820° F.* *1920° F.*

Fig. 1 – Oxidation of Chromel-P Heated for 48 Hr. in Contact With Oxidized Nickel Foil in Evacuated Quartz Tubes. Unetched; 100 ×

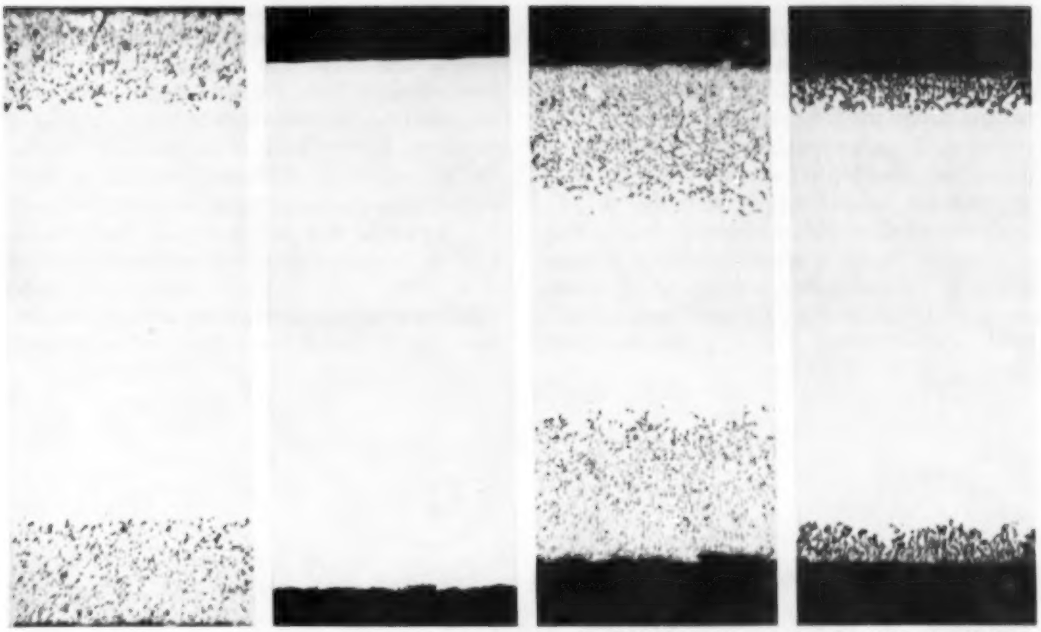
thermocouple protection tubes. The samples were oxidized intergranularly in varying degrees; they became strongly magnetic and developed brittle surface cracks at the penetrated area when bent. Although the samples were too short to check for thermal emf., they would have given low values depending upon the depth of corrosion. The nickel foil used for the sample at 1820° F. changed from an oxide finish to a perfectly bright finish, indicating that it lost all of its oxygen to the Chromel-P.

A theory was developed for the change in emf. of thermocouples in seemingly good protection tubes. With an inadequate air supply (as in a tube with the cold end partially or totally closed, or in a long, narrow tube, especially if insulators filled most of the tube), the oxygen is depleted initially by normal oxidation of the thermocouple wire and the inner surface of the protection tube. When the oxygen reaches a critical low partial pressure then intergranular oxidation of the Chromel-P begins. If the tube is completely sealed, the action can be supported by oxygen contained in the oxidized surface in the tube or an oxide finish on the wires. A metal tube should be worse than a refractory tube and an unalloyd iron or steel tube would be worse than a stainless tube because of the two

Table II – Effect of Protection Tube Variables on Thermocouple Corrosion
(18-Gage Bright Chromel-Alumel)

Protection Tube	Furnace Atmosphere	Hot Junction	Time Hr.	Error, °F.*
S.A.E. 1015, 0.50 in. O.D., 0.25 in. I.D., 2.5 ft. long				
Sealed	Hydrogen‡	2000° F.	18 hr.	−113° F.†
Sealed, Ti wire inside	Hydrogen‡	2000	18	−7†
Cold end open	Air	1650	23	−20
		1830	23	−85
Sealed, Ti wire inside	Air	1650	23	0
		1830	23	0
Inconel, 0.675 in. O.D., 0.493 in. I.D., 3 ft. long				
Sealed	Air	2150	24	−160
Sealed, Ti wire inside	Air	2150	24	0
Cold end open	Air	2150	24	−140
Cold end open, Ti wire	Air	2150	24	−20

*Guarantee as sold is ± ¾% (±12° F. at 1600° F.)
†Error at 1600° F. after exposure; other errors during exposure.
‡Dew point 75° F.



Sealed Sealed, Ti Wire Cold End Open Cold End Open, Ti Wire

Fig. 2 – Effect of a Titanium Wire on Corrosion of Chromel-P Held for 24 Hr. in the 1500° F. Zone Inside an Inconel Protection Tube. Unetched; 100 ×

conditions necessary – initial oxidation and subsequent release of that oxygen to the chromium of the Chromel-P. This has been borne out in observations of useful thermocouple life in laboratory tests. The operating temperature of the thermocouple hot junction could be anything above about 1500° F. because even though the hot junction were above the upper limit of the corrosive temperature zone (about 1900° F.), a segment of the wire would be in the critical zone and the effect on the thermal emf. would be just as marked.

If the stagnant air supply, the oxidized surface of the protection tube and the oxide coating on the thermocouple wires are the main factors in causing the Chromel-P to develop calibration errors, then it logically follows that if all oxygen is excluded from the tube the thermocouple life should be almost indefinite. It is also logical that if a material such as titanium, which has a greater affinity for oxygen than chromium, were placed inside the protection tube, the preferential oxidation of chromium would be further reduced or eliminated.

The results in Table II show how corrosion can be prevented by the exclusion or scavenging of all oxygen. The effect of available oxygen from entrapped air or refractory insulators is illustrated by the large errors developed in the

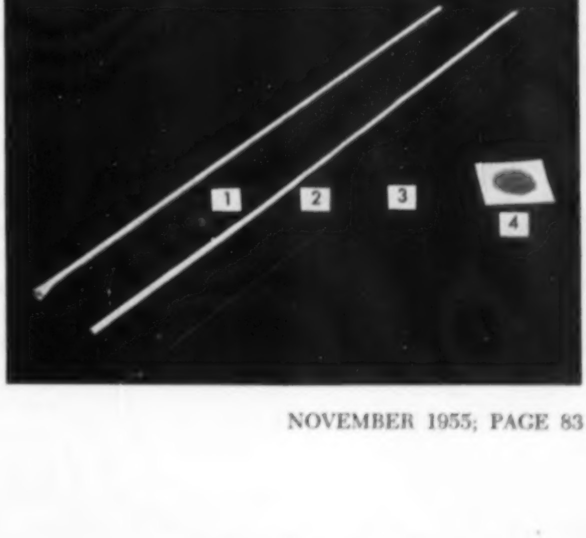


Fig. 3 – Component Parts of Protection Tube Assembly. (1) Inconel tube, 0.675 × 0.493 × 36 in., welded at hot end, acid pickled inside to remove all oxide. (2) Bright 18-gage Chromel-Alumel wire with 2-hole insulators. (3) Titanium wire, 0.063 in. in diameter. (4) Alundum cement for sealing end

sealed tubes. When titanium wire is inserted in such assemblies, there is little or no corrosion. With open-end protection tubes, the small amount of oxygen that leaks in through the cold end reduces the error slightly, but with the long narrow tubes used in these tests the error is excessive. The titanium definitely helped use up the oxygen in an open tube but could not keep up with the oxygen supply from the air.

Micrographs of the Chromel-P wires after exposure in Inconel protection tubes are shown in Fig. 2. The correlation between depth of corrosion and the error in thermal emf. is quite good. The corrosion shown is the maximum along the wire at the section that was at 1500° F.

In these tests titanium was used as the "getter" to avoid elaborate means of evacuating or purging the tubes and then making a perfect hermetic seal. Use of a getter allows for some imperfections in the evacuation and sealing processes, but the tests do not indicate whether the getter can be eliminated entirely by thorough cleaning, evacuating or purging, and sealing. It may be that oxygen derived from the refractory insulators alone will necessitate the use of a getter.

In any event the simplicity of the test assembly (see Fig. 3 and 4) and the results obtained,

Book Review...

Pattern of Titanium Research

*Reviewed by M. A. HUNTER**

TITANIUM IN IRON AND STEEL, by George F. Comstock; Alloys of Iron Research Monograph Series, John Wiley & Sons, New York, N. Y., 294 p., 1955. $6.00.

THE HISTORY of titanium in industrial technology is a fine illustration of the impact of research – both basic and applied – in the development of ideas in a new metallurgical field. The progress is not continuous. Waves of interest advance the forefront of knowledge in a certain direction until further movement in that direction is blocked by lack of knowledge or of equipment for continuation. When new information from collateral fields appears, further progress can then be made. The full realization comes only from the summation of effort from many directions.

The metal titanium is a case in point. Titanium was isolated as a chemical element late in the eighteenth century. The description of attempts at its isolation by chemical or electrolytic means is distributed through the literature of the nineteenth century. Many of the observers produced titanium metal as fine powders or as small dendritic crystals which found little or no use in industrial applications. Ferro-alloys of titanium could be made and were made as the only source of metallic titanium available to industry. The metal which ranks ninth among the elements present in the crust of the earth played but a small part at this time in the industrial picture.

The first massive titanium appeared in October 1906 when the present reviewer reported the production of massive titanium by a process which Comstock somewhat reluctantly refers to as the

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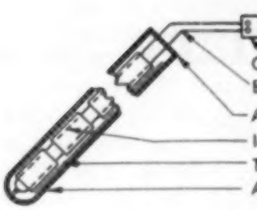

Fig. 4 – Sketch of Assembled Unit

indicate the commercial possibilities of these protection tube principles.

With properly prepared tubes, it should be possible to use smaller tubes and smaller wire for certain applications. The advantages would be cost savings, greater sensitivity and response, and perhaps longer and more dependable service life.

Although Chromel-Alumel thermocouples do not melt below 2550° F., the maximum recommended operating temperatures range from 1600° F. for the fine wire sizes up to 2300° F. for the very heavy sizes, based upon a reasonable service life in an oxidizing atmosphere. With good oxygen protection in a sealed tube permissible operating temperatures might be much higher, particularly for the finer wire sizes.

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so-called "Hunter process". But the attempts of Comstock, of the Titanium Alloy Mfg. Co. at Niagara Falls, and of Hunter at Rensselaer Polytechnic Institute, to develop titanium production by the sodium reduction method could not advance because no method was available for melting the coherent titanium produced. The method of melting under argon or helium was unknown since both of these gases were laboratory curiosities in the spectroscopic tubes of Sir William Ramsay in London.

The present development in the production of titanium sponge dates from the work of Kroll, in 1940, when adequate melting of the titanium product could be carried out in the absence of the air contaminants – oxygen and nitrogen.

In the interval between 1910 and 1940, George Comstock maintained a continuing interest in titanium metallurgy as director of research with the Titanium Alloy Mfg. Co., under the direction of its president, W. F. Meredith. Through their activities the metal was available as a ferrocarbon titanium. (A second source of titanium was aluminothermic material produced by Metal & Thermit Co.). In this volume "Titanium in Iron and Steel", George Comstock leaves to posterity a full and complete record of the developments in titanium metallurgy in which he played a prominent part during his more than 40 years in the field. In his present retirement his friends and associates compliment him for a job well done and wish him equivalent satisfactions in the years that lie ahead.

From the table of contents covering the applications of titanium in this period, the various chapters deal with the use of titanium in the control of oxygen and nitrogen in steels and cast iron, the fixing of carbon in the stabilization of stainless steels and the control of enameling irons. In these applications the thermodynamic properties of titanium oxides, nitrides and carbides – which retarded the development of titanium-base alloys – have been put to good use in the control of interstitial components in alloys with an iron or a nickel base. The concluding chapter, which deals with precipitation hardening alloys of nickel or iron, covers the use of titanium in heat resisting alloys for use in gas turbines for jets and high-speed plane applications. The high-temperature strength of these alloys comes from additions to titanium and aluminum and their precipitation by heat treatment.

It would be quite hopeless to criticize the vast accumulation of empirical and pertinent data on titanium additions which the book contains. This reviewer would, however, question the statement made on page 29 that "titanium master alloys, widely used in steelmaking, are of far greater importance at present than high-purity titanium metal". The saving grace in the statement is contained in the words "at present". For in spite of the over-glamorization which has prevailed in the development, I believe that titanium and titanium-base alloys are destined to play a great part in the future metallurgical economy. The master alloys for the steelmaker may possibly come in the future from the titanium scrap of a major titanium industry.

Our Biographical Dictionary . . .

William Trehane Ennor
Albert Sauveur Achievement Award, 1953

One of the truly revolutionary processes used by the metal industries is the direct chill or "D.C." casting of aluminum ingots. Molten aluminum, poured into a shallow, water-cooled aluminum mold is drawn downward and emerges as a solid ingot. Ingots can be cast in large size and almost any cross section; more than one can be made side by side in the same apparatus if necessary. Length of ingot and its weight is restricted only by the requirements of the mill and the range of movement for the hydraulic platform that gradually lowers the ingots down through the ring mold.

This D.C. process – a vital step in the efficient

production of aluminum fabricated products of high strength – is the brainchild of modest, likeable William Ennor, now assistant director of Alcoa's Aluminum Research Laboratories at New Kensington, Pa. Its discovery is a fine example of a production problem carefully investigated by the scientific method – and solved – and well warrants the A.S.M.'s award of the Albert Sauveur Achievement Plaque.

It may be recalled that as recently as 1910, aluminum (like copper) was a soft metal that could not be hardened by quenching and tempering – the ages-old method for steel. The Germans, however, used a strong and hard aluminum alloy in their aircraft in World War I. American metallurgists quickly devised several hardenable alloys and the necessary heat treatments, but these alloys had an almost uncontrollable tendency to segregate badly while the ingot was solidifying and to crack during hot working. Two of Alcoa's engineers, T. D. Stay and Wm. Holzhauer, devised methods for minimizing these effects by "water-dipping" wherein a hot cast iron mold filled with molten aluminum alloy is gradually lowered into a cold water bath. This method gave satisfactory rolling and forging ingots up to 8 × 8 in. in cross section.

This was the situation in 1929 when the installation of a 38-in. blooming mill at Alcoa's Massena, N.Y. works required aluminum ingots of an unprecedented size. Bill Ennor, then chief metallurgist at the works, attacked this problem; working with him was the assistant works metallurgist, W. E. King.

Conventional tilt molds would not do, so they tried the bathtub mold which is a horizontal trough that tapers in toward the bottom. The bathtub gave a sound ingot, but its taper caused warping in the blooming mill. To overcome this defect, a long, hot cast iron mold, tapered from one end to the other, was used. After pouring, the ingot was progressively cooled by lowering the mold on a platform through a heating chamber and water spray ring. This was an adaption of Stay and Holzhauer's earlier water-dipped process.

At this point, Bill Ennor hatched the idea that solved the problem. If the metal were poured in a shallow, water-cooled aluminum mold with a retractable bottom, Ennor reasoned, the outer shell would freeze before the ingot emerged from the mold. As the bottom was lowered, this solidified shell would serve as its own mold wall while a water spray rapidly cooled the ingot through to the center.

The bugs were worked out of the new process by 1934. Two major advantages were achieved: Workable ingots of desired size and shape were produced, and at the same time the secondary constituents in the microstructure – so necessary for the subsequent hardening treatments – were distributed edge to center and end to end in wholly unprecedented fineness and uniformity. It works so well that all the aluminum and magnesium mills on the North American continent use it for practically everything except for foundry and remelting stock.

Such a contribution to the metallurgical art is one the like of which few men make in a lifetime, but Ennor's aggressive, inventive mind has been continually productive. He did extensive work on the perfection of aluminum screen cloth, the development of Alclad wire and the improvement of aluminum wiredrawing processes. Other notable work includes development on rolled forging stock, structural shapes and metal transfer methods.

William Trehane Ennor was born just 16 days after the turn of the century in Potosi, Wis. He attended the University of Wisconsin and received a B.S. degree in chemical engineering in 1923, also being awarded memberships in Tau Beta Pi and Phi Lambda Upsilon.

After graduation, he stayed on for a year as instructor in chemical engineering before joining Aluminum Co. of America at New Kensington. Important steps in his advances with Alcoa were jobs first as technical supervisor and later chief metallurgist at the Massena works. In 1943, he became assistant works manager at the plant then operated by Alcoa in Newark, Ohio, for the U. S. Government. In 1948 he became an assistant director of research at the Aluminum Research Laboratories – the position he holds at the present time.

W. T. Ennor married Davina Henderson in 1925; they have two charming daughters – Margaret Jean and Barbara Mary.

Bill Ennor hasn't spent all of his life with a slide rule in his hands. As most of his friends will verify, he finds time for golf. After observing how he swings the driver, a new opponent will chuckle and calmly get ready to dust off an easy opponent. More often he comes in a flabbergasted second in spite of Mr. Ennor's questionable form. He plays his golf at one of the nation's toughest courses – the Oakmont Country Club, near his residence. And if you're afraid to tackle him at golf, Bill Ennor is an enthusiastic opponent at tennis, bridge, bowling or badminton.

Metal Whiskers in Automatic Blanket Thermostats

*By J. B. NEWKIRK**

Tiny filaments found in thermostats from used automatic blankets are single crystals growing from the cadmium plating. (N 5, M 26, L 17, Cd)

Several small thermostats were removed from two automatic electric blankets made by a large manufacturer which had been in service for two years. It was found that the inside walls of some of the boxes were covered with a forest of shiny filaments so thin as to be barely visible to the naked eye. The filaments are believed to be single crystals of cadmium that grew after the blanket had been put into service. These hair-like crystals might not necessarily lead to failure of the appliance but they should be avoided in low-current devices where they could cause short circuiting. Thermostats of this type are no longer used generally in automatic blankets but are used in several current models of heating pads.

Whisker-infected thermostats have been found in both full-bed and twin-bed blankets. The locations of the thermostats in the latter type are shown in Fig. 1. All the thermostats in this blanket break 1.17 amp. at 115 volts. They are set to open the circuit at $150 \pm 5^{\circ}$ F.

The temperature-sensitive element of the thermostat is a bimetallic strip[1] contained in a small box made of cadmium-plated steel sheet. The box, with insulated lead wires, is wrapped with one layer of gauze and then is hermetically sealed in a white insulating sleeve (Fig. 2). The practice at the time these blankets were made was to include a few drops of an oily sebacate as a plasticizer for the flamenol used for the wire insulation and the sleeve around the thermostat. (When trouble arose, due to bleeding of the sebacate out of the flamenol, the plasticizer was changed to octyl-decyl-phthalate.) The inside surfaces of about half of the 14 thermostats examined showed the condition illustrated in Fig. 3. Rarely, hairs were

*Research Associate, Metallurgy & Ceramics Research Dept., General Electric Co., Schenectady, N.Y.

also found growing on the outside of the box. None has been found on a cover.

The thermostat cases and their covers were made of low-carbon steel sheet cold rolled to quarter-hard and a bright surface. Before forming the parts, the sheet was electroplated with cadmium to a nominal thickness of 0.00015 to 0.0005 in. The actual thickness of the plate was not checked.

Every fiber observed had an apparently uniform thickness over its length and was attached by one end to a side of the box. The longest one found was about 3/32 in. When examined in an electron microscope their cross section appears to be round. The thickness of the fibers is of the order of one micron (0.00004 in.). Their strength appears to be very high since the fibers can be severely bent without becoming permanently deformed. They offer little resistance to the flow of electricity. By careful handling, a few of the filaments could be mounted in an electron diffraction camera. The diffraction pattern so obtained corresponded to patterns which would be given by single crystals of metallic cadmium. It is therefore concluded that the fibers are actually single crystals of cadmium.

Fibers similar to those described were first

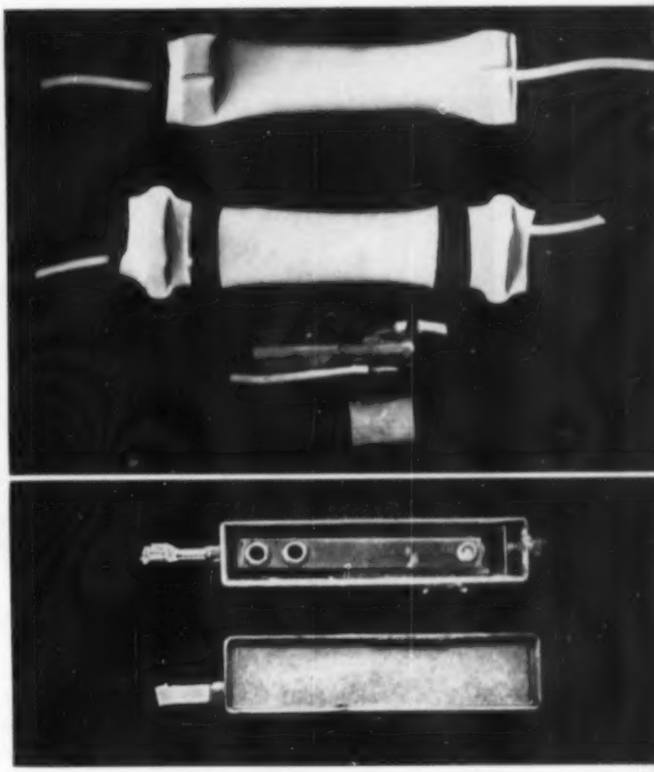
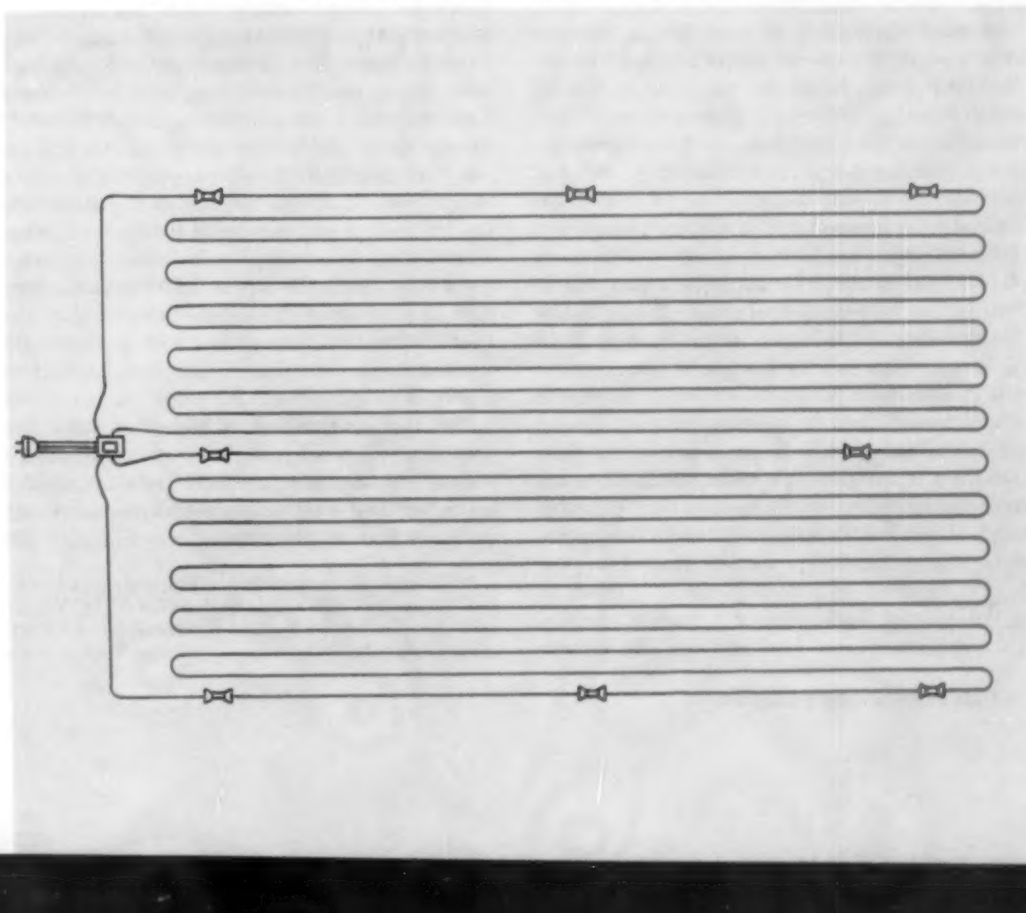


Fig. 2 – Thermostat Assembly

Fig. 1 – Location of Wiring and Thermostats in an Automatic Electric Blanket



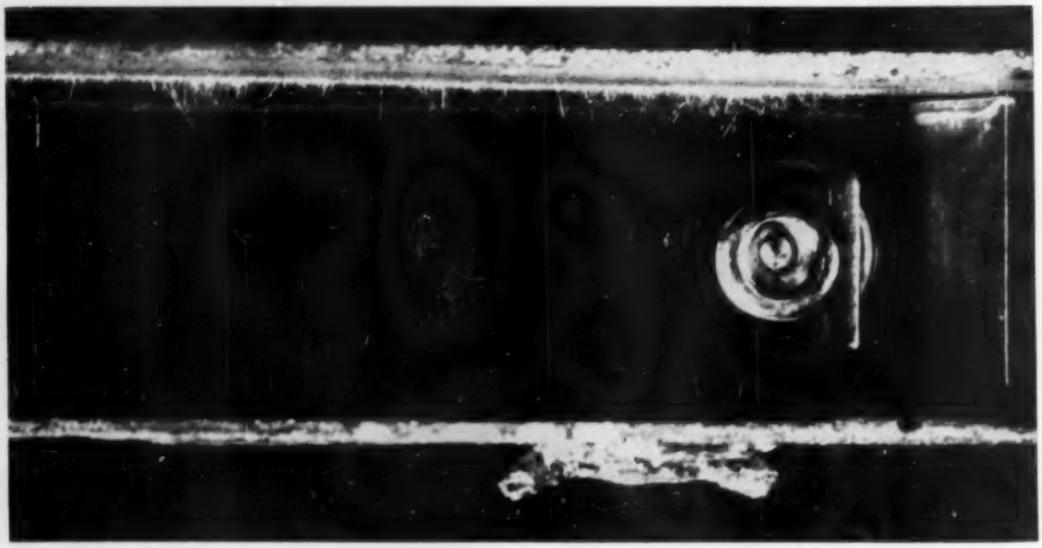


Fig. 3 – Metal Whiskers Growing From Sides of a Thermostat Case. 10 ×*

reported in 1946 after they were discovered on the cadmium-plated variable condenser plates of a ten-year-old radio. The nature of the growth was not known until five years later when the hairs were identified as single crystals of cadmium having a high degree of lattice perfection. Since then, fibers of this sort have been found on the surface of several metals, including tin, cadmium and zinc, which had been held only slightly above room temperature.

This curious variety of crystallite is believed to be a result of a special sort of recrystallization. The fiber grows from the base, being fed by metal from neighboring grains. Growth mechanisms for metallic filaments have been suggested that involve a dislocation at the base of the fiber, the driving force for the reaction being derived from atmospheric oxidation. The growth of tin hairs is accelerated up to 10,000 times (0.04 in. in 16 min.) by applying a pressure of 7500 psi. on tin-plated steel sheet. This indicates that the driving force may come from residual (coherency) stresses in the plated metal.

Whatever may be the mechanism of growth of metallic whiskers, it appears that poor plating practice is the greatest factor in promoting their formation. Conditions associated with filaments on cadmium-plated steel include a thin, pitted or rough deposit with impurities occluded in the plate. These conditions can be caused by improper cleaning of the base metal, impurities in the plating bath, improper current density and even insufficient final rinsing. The growth of crystal filaments apparently cannot be avoided by merely coating the metal with a superficial covering such as lacquer. Metal whiskers penetrate such a film with ease.

The sort of filament crystal found in the thermostats should not be confused with another type of metallic fiber which grows from the vapor phase at temperatures that are usually hundreds of degrees above room temperature. Recently fibers of several metals, including mercury, silver, copper and iron, have been grown from the vapor phase. This type is believed to have a spiral dislocation along its axis and receive its nutriment by the impinging of vapor atoms upon it. Atoms arriving at the atomically smooth surface on the sides of the filament either bound away again or migrate over the surface until they reach the tip of the filament where they deposit upon the regenerating step of the spiral dislocation, thus adding a bit to the length of the fiber. Crystals of this sort have been observed to grow from the tip.

Finally, nonmetallic hair-like growths are occasionally found on the surface of metals which have been exposed to certain corrosive materials. The most common of these are found on silver and on aluminum.

*The crystal structure of the filaments was identified by electron diffraction analysis by N. M. Walter and the photographs were prepared by A. Gatti of this laboratory.

Batch-Type Strip Annealing Furnaces

By C. F. OLMSTEAD*

Advantages of multiple and single-stack cover furnaces for process annealing of strip include lower fuel or power costs, shorter annealing cycles and more uniform product. (J 23)

APPROXIMATELY 25,000,000 tons of steel products are process annealed annually for subsequent cold rolling or drawing. The largest tonnage is cold rolled steel sheets, then tin plate, wire and strip in that order. Such items account for nearly 40% of all finished steel production. In addition, substantial tonnages of copper and aluminum products are similarly annealed to soften for rolling, drawing or forming.

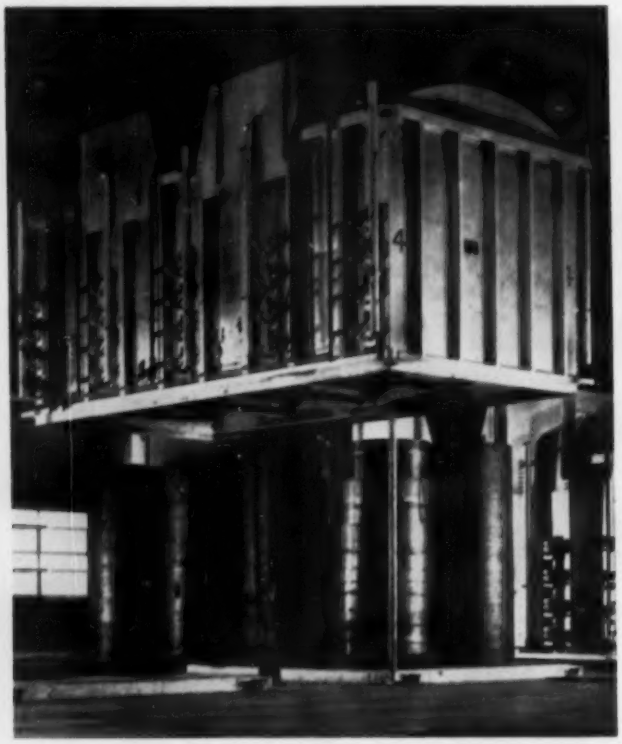
For 15 or 20 years, the batch-type "cover" furnace has been the work horse for the wire and strip annealing industry, although some annealing has been done in continuous strand annealers, in car-bottom tunnel furnaces and in ball and pan furnaces. Only a few of the latter type are left.

A cover furnace is welded gas-tight on the sides and top and has heating units of one kind or another on the side walls. When the furnace is lowered on the base, its perimeter is sealed with sand or liquid, tight enough to exclude air when protective atmospheres are used. Before 1930 high-carbon steel and nonferrous wire and strip were generally annealed in cover-type electric furnaces. Cold rolled sheet and tin plate were stacked flat, loaded in heavy cast steel boxes sealed with clay and shoved into thick-walled furnaces. The heating and cooling cycles were very long. In the middle of the 1930's the gas-fired radiant tube was substituted for electric heating elements and delivered clean heat at lower cost wherever natural gas was available.

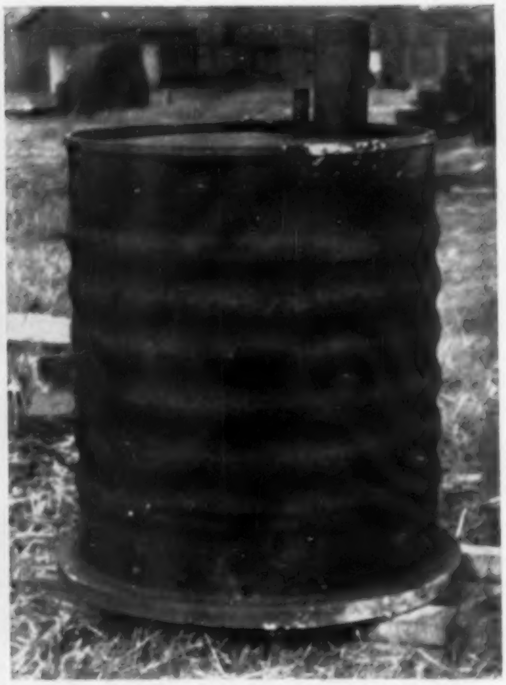
Cover-type furnaces were designed and used for annealing low-carbon cold rolled sheet and tin plate. The charges were stacked on bases and covered with rectangular inner shells to exclude air after purging with protective atmosphere gas. The heating cover was brick-lined, complete with combustion equipment and portable when disconnected from flexible fuel, power and thermocouple outlets.

The advantages over the old in-and-out furnaces were that the heating cover could be lifted as soon as the charge was at temperature and be lowered over another charge without loss of heat in the brickwork. The heated charge, free of the furnace but protected by the inner shell, cooled faster so that it took less time and fuel to anneal the steel. The saving was substantial enough to encourage heavy investments for replacements in the middle of a depression. In the subsequent expansion of capacity new annealing departments were almost without exception equipped with cover-type furnaces.

*President, Lee Wilson Engineering Co., Cleveland. Paper for Industrial Heating Equipment Association, presented at National Metal Congress, Philadelphia, Oct. 18, 1955.



Rectangular Cover 8-Stack Furnace. (Courtesy Swindell-Dressler Corp.)



Original Radiant-Tube Cover Furnace – a Refractory-Lined Oil Drum and a Stove Pipe

During this same period hand mills were being replaced by continuous tandem mills and the product to be annealed was in the form of coils instead of flat sheets. The first coils were small and were annealed in the same furnaces as the sheets and covered by the same inner shells. Eventually the coil sizes grew as mills were built for faster speeds and greater widths. The distortion of rectangular inner covers increased to a point where it was more economical to cover each stack with a separate cylindrical "ash-can" cover. Furnaces were designated according to how many of these individual inner covers they would accommodate and we now have 2, 3, 4, 6, or 8-stack furnaces.

Hundreds of these multiple-stack furnaces are in use today and they have annealed hundreds of millions of tons of steel. Some recent improvements include the use of more powerful base fans and separator plates to get more circulation around the coils and through them and changes in design of inner shells to improve heat transfer by a combination of radiation and convection.

Single-Stack Furnaces – Actually, single-stack cover furnaces were in use before the first multiple-stack furnace was designed. The early ones were electric and were used for annealing wire and narrow strip. They are still used extensively for this purpose, especially for high-temperature annealing.

The radiant-tube single-stack furnace has had wide use in the wire and narrow strip business ever since it was introduced because of lower fuel costs compared to power rates. The first radiant-tube cover furnace was actually a single-stack furnace. It consisted of some stove pipe in an old oil drum!

It is interesting to contemplate, in the light of this history, why single-stack heating for wide strip was not promoted and accepted along with multiple-stack furnaces, for it has only been in the last few years that these units have been taken seriously for large tonnages of wide strip. By the end of 1955, however, there will be about 300 units for this purpose alone.

The single-stack furnace has certain advantages, irrespective of the method of heating or the product to be annealed.

1. The shape of the furnace conforms to the shape of the charge and heat is radiated at an equal distance from all sides.

2. A maximum amount of heat-reflecting sur-

Complete Installation of Single-Stack Furnaces for Annealing Strip With Covers, Inner Shells and Coolers. (Courtesy Westinghouse Electric Corp.)

face in the furnace walls is provided in relation to the receiving area of the charge. Heating is therefore rapid and uniform. The fast heating rates compensate for the increased wall radiation area of single-stack furnaces and the fuel or power cost per ton of material heated is comparable to any other method of heating.

3. There is a minimum amount of inventory in process because whenever a small amount of similar material is accumulated for annealing, it can be loaded and heated without loss of time or heating efficiency. This also means fast delivery to the customer.

4. The heating covers of single-stack furnaces are comparatively light. In mills making cold rolled sheet and tin plate the coils are usually heavier than the furnace and determine the size of the crane and the strength of the building columns.

5. Single-stack units capable of handling the largest size coils are small enough in over-all dimensions to be shipped in one or two sections, completely assembled with lining, combustion equipment and controls, ready for service when lifted from the flat car or truck. This is an advantage for the buyer who is spared the inconvenience of providing space, labor, crane service and facilities for assembly in his plant. These light covers are used efficiently – they can be handled on a periodic schedule so that only one hot inner shell is exposed at any time. These inner shells are spaced far enough apart so that forced fan coolers can be lowered over them to speed up cooling and to deflect the heat toward the roof monitors, instead of reflecting it to the discomfort of the operators. Loading and unloading can be arranged so that inner shells and coil spacers, lifted from a cooled charge, can be set directly on charges being made up, thereby minimizing handling and storage space.

6. Better uniformity of product can be expected. Each stack or charge is directly and separately controlled during its heating cycle.

7. Production per unit is large. Small charges are heated independently at a faster rate than larger charges and the resulting output per furnace is high irrespective of the load factor. For example, a typical furnace might be over a 24-ton charge for a total of 10 hr., for a heating rate of 2.4 tons per hr. If the same furnace is placed over a 60-ton charge of the same material, it will require about 20 hr. for a heating rate of 3.0 tons

Combustion System for a Single-Stack Portable-Base Annealing Furnace (Lee Wilson Engineering Co.)

per hr. For a decrease of 60% in load, there is a loss of only 20% in heating rate.

8. Because of the fast heating and economical loading, floor area required per ton of product heated is very low. Foundations can be made very simple, with portable bases that can be lifted out and replaced by an extra for motor, fan or lining repairs. A shallow trench to accommodate the fan motor, power lines, thermocouple leads, fuel pipes and atmosphere supply lines is all that really is required.

It is entirely reasonable to expect these things of a modern cover-type strip annealing furnace:

1. A wide enough temperature range and sufficient uniformity to anneal the product to close tolerances – providing prior steelmaking practice imposes no handicaps. The furnaces are designed to anneal steel and not to make it.

2. Capacity large enough to handle a full range of widths and thicknesses.

3. The ability to produce a bright surface consistently without sealing problems. Of course, the atmosphere gas must be delivered at the correct composition and dryness.

4. A design that will permit changing from one fuel to another, without serious loss of time for dismantling and with a minimum of expense.

5. Fast enough operation to give quick delivery to customers and a minimum of material in process.

6. Minimum requirements of labor and skill for operation with maximum safety and comfort to operators.

7. Rugged construction to assure low maintenance and a minimum of lost production for shutdowns.

8. Low fuel and power consumption.

9. Minimum cost for all items of building and handling facilities.

Production fluctuates but the trend is ever upward because of the rapid growth of population and the higher per capita consumption of annealed products. These products will be annealed in either obsolete or modern equipment. If an employee steals profits, he is quickly replaced. Why should obsolete equipment be treated any less drastically?

The competitive situation in the furnace industry is such that its most progressive members do a great deal of research and development to stay in business. No buyer is safe in assuming that the equipment he bought last year will give him full advantage of modernization in the industrial heating equipment industry.

Mechanized Continuous Furnaces

By GEORGE C. McCORMICK*

Existing successful machines are classed six ways according to method of handling work, advantages and disadvantages of each type briefly stated, and some major considerations are presented which affect a decision to mechanize a heat treating department. (J general)

I PROPOSE to select some information, sketches and illustrations of mechanized heat treating furnaces of the continuous type from a great amount of those available to my company and its cooperating associates in the Industrial Heating Equipment Assoc. It is my hope that it will inform the young and less experienced engineer, and also that it may stimulate the imagination of the older ones and induce action. Furthermore that it may be seen and read by men in management and will induce them to examine their heat treats – that department so often neglected when other manufacturing operations are improved and modernized.

Let me say with confidence and emphasis that there is no section of industrial operations in which there is more antique and obsolete equipment than in heat treating. A good look by top management at their heat treating operations followed by appropriate action may easily uncover a pot of gold.

What follows is not about automation. It is rather a presentation showing installations that are in successful operation, replacing primitive equipment, and turning out a superior product at less cost.

At the end I will examine briefly the factors involved in deciding whether or not to mechanize a particular heat treating operation. Let us now examine some of the arrangements that have been put in successful operation. The illustrations which can be presented in rather limited space by no means cover all the types of mechanized furnaces but they represent, I believe, a fair selection. For convenience, the equipment will be subdivided according to the way the parts are conveyed through the furnace and its auxiliary equipment, if any:

1. Part pushes part.
2. Part travels around a rotary hearth.
3. Parts are on pusher trays or carriers.
4. Parts are moved on walking beams.
5. Parts on conveyor belt or shaker hearth.
6. Parts in rotating drum with internal spiral.

Part Pushes Part – ordinarily this involves a furnace with rollers, properly spaced, as a

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bottom. Rollers are of heat resisting metals, or may be internally cooled by water. Ordinarily the rollers idle, in which case a pusher is needed to advance the furnace load at pre-set intervals. Parts so treated must of course be large enough to span at least three rollers, have a flat surface to ride upon, and more or less boxy shape so they can push the train ahead without buckling.

One of our leading automotive manufacturers saves not only imperfect cylinder blocks but also time, manpower and floor space by using the unique arrangement shown in Fig. 1 for preheating and annealing 5200 lb. of salvage castings per hr. The furnace is loaded at the right side of the far end. Properly preheated castings come out periodically on the table behind the operator, are transferred quickly to welding benches, repaired, placed ahead of the pusher at the rear left side and put through the furnace in a counterflow manner. The complete process involves heating slowly to 1100° F., welding, and annealing the repaired castings at 1100° F. The furnace has a heating chamber at the near end; castings are loaded and unloaded at the far end. The cold castings, as they approach the heating zone, are slowly preheated by the welded castings, which are being annealed on the return trip.

Rotary hearth furnaces are well known. They are turret shaped externally and usually direct fired. The one shown in Fig. 2 has a hearth 60 in. diameter, and will heat 1200 lb. of work per hr. to 1600° F. Construction is such that the roof and sidewalls are supported independently of the hearth and can be lifted off when necessary. A circumferential sand seal closes the opening between sidewalls and hearth except at the door. The lower edge of the door is below the hearth level when closed.

Advantages and disadvantages of rotary hearths will be noted – along with those of other classes – at the end of this article.

Trays and Carriers – Trays are ordinarily for fairly small parts; carriers may be of infinitely variable design, the fixtures being adaptable to the shape to be handled and should be easily loaded and instantly unloaded. They are usually pushed through the roller-bottomed furnace. However, Fig. 3 shows a type of mechanized furnace referred to either as a roller-bottom or roller-hearth unit in which the work may be carried in baskets (or, if the work has one broad flat surface as in cylinder blocks, no carrier is necessary). Units of this general construction are applied to a wide variety of operations including brazing, carbon restoration of bar stock, malleable annealing, and heat treating of such things as harrow disks.

Roller bottom furnaces such as the one shown in Fig. 3 may have sectionalized roll drives which rapidly charge the work, rapidly transfer it from heating to cooling chamber ,and rapidly discharge it – all this as well as door operation automatically by electric eyes or limit switches. The entire charge can be brought back to the loading position so the operator's only function is to load and unload the trays.

Small parts can be fed into the trays at a controlled rate to a continuous annealing furnace by metering loaders which distribute the work very uniformly on the carriers.

Many variations of this general "tray and carrier" idea are possible, such as in methods of heating, single or double lines of

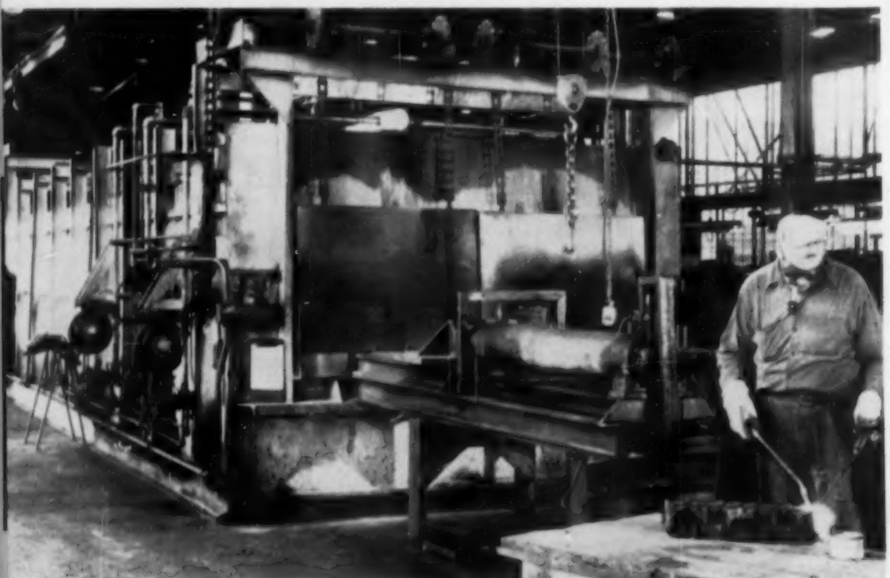


Fig. 1 – Counterflow Furnace for Preheating Automotive Castings Prior to Welding of Defects and Annealing of the Repaired Items

carriers, atmosphere control, and especially in arrangements for automatic loading, unloading, and quenching. For example, an efficient in-line arrangement is one in which the work is carried on trays through the hardening furnace, extracted to a tray-dumping mechanism which drops the parts into the quench tank through a chute, then to be caught by a conveyer-elevator taking the work from the quench tank to the apron of the continuous draw furnace. In this instance the trays go through the roller-hearth hardening furnace and return automatically to the loading end; the draw furnace has an alloy belt supported on closely set alloy rollers.

Units of much more modest size are of course available. One, hardly 20 ft. long over-all (including pusher and above-floor quench tank) is a carburizing unit, fired with radiant tube, through which the work in trays is pushed, and extracted from the heating chamber by a hydraulically operated go-getter. This places the tray in a cage, still under protective atmosphere, which revolves 180° to dump the work through a chute into the oil quench. The cage then returns to its normal position, a side door on the discharge vestibule opens, the basket is pushed out of the cage, and a gravity conveyer returns it to the charging end of the unit. Meanwhile the work is being discharged from the quench tank by a flight conveyer.

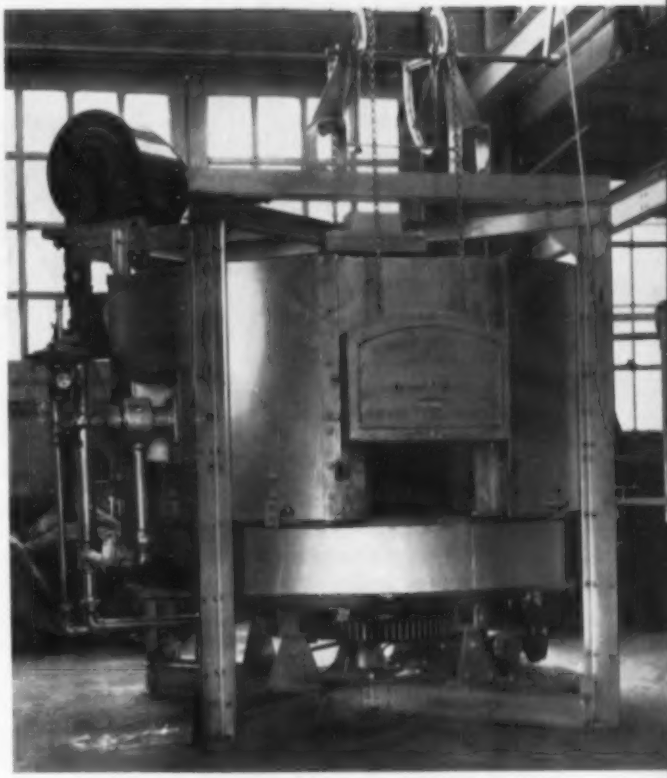


Fig. 2 – Rotary Hearth Furnace, Direct Fired, for Heating 1200 lb. per Hr. to 1600° F. (Courtesy Industrial Heating Equipment Co.)

At the other extreme, some of the furnaces are extremely large, especially those capable of annealing malleable iron in a controlled short cycle at the rate of 50 tons per day or more. The stock is protected from oxidation by controlled atmosphere, and is usually carried in baskets or boxes. These furnaces can be set on stilts, clearing the floor by 7 to 10 ft. which gives that much area, otherwise occupied by the furnace, for stock storage or other purposes.

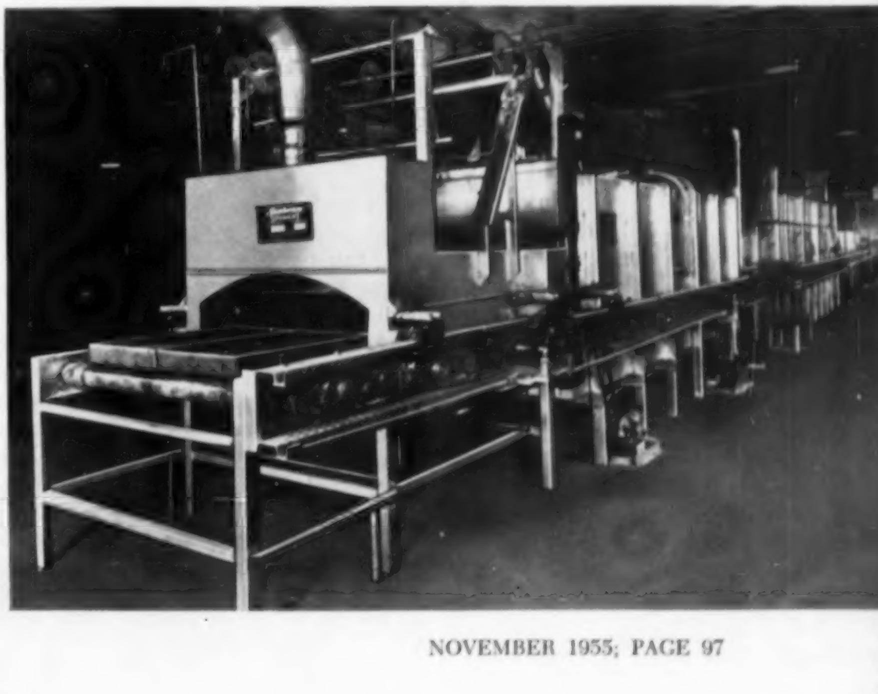


Fig. 3 – Roller-Hearth Furnace With Rollers Sectionalized and Driven at Proper Speed for Charging, Heating, Holding and Cooling Zones. (Courtesy Sunbeam Corp., Industrial Furnace Division)

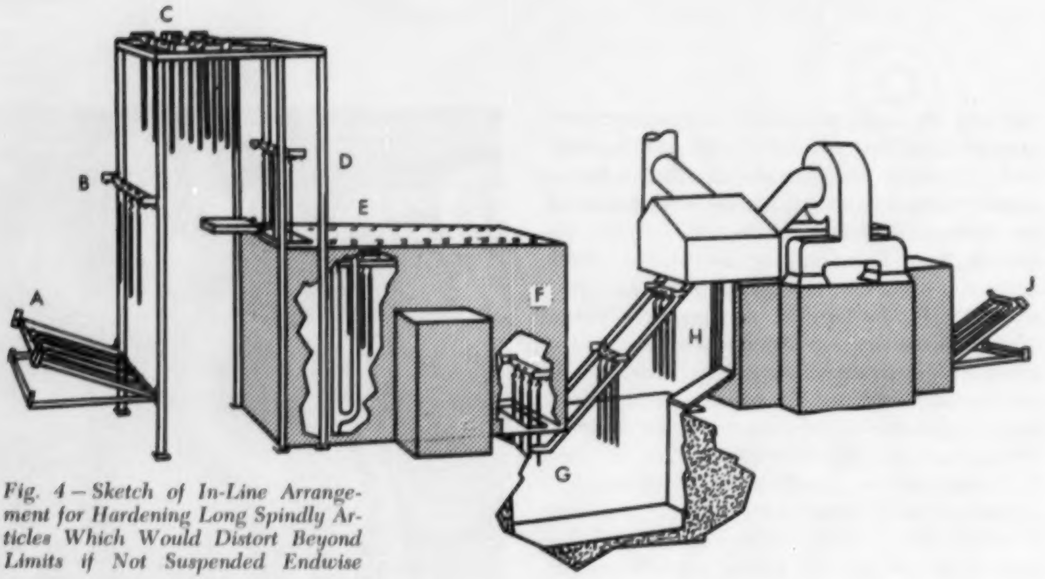


Fig. 4 – Sketch of In-Line Arrangement for Hardening Long Spindly Articles Which Would Distort Beyond Limits if Not Suspended Endwise

Walking Beams – Figure 4 is a perspective sketch of a mechanized line which consists of a gas-fired radiant tube furnace with controlled atmosphere for hardening, followed by an automatic quench and then a tempering furnace where heating is done by convection in a forced recirculating atmosphere. The long axles are hooked on a carrier while in a tray near floor line, brought to a vertical position and raised by elevator *B* to the transfer mechanism *C* to a position directly over a door in the furnace roof. Elevator *D* lowers the carrier into the furnace where it is deposited on a walking beam (or rail and chains) which pull the work through the furnace, finally reaching the elevator into the discharge chute *F*. Bars descend into the oil quench *G*, are carried from the oil quench up an inclined conveyer to the tempering furnace *H*. When discharged from the draw furnace they are lowered into a horizontal position by the pivoted crane *J* for unloading.

This type of unit is suitable for torsion bars, axles, crankshafts and other similar parts which are prone to distortion. A unit of this type has been built to produce 215 axles per hr., heating a gross load of approximately 6600 lb. The entire line – harden, quench and draw – is handled by one operator. This replaces previous equipment producing 130 shafts per hr. with three operators. Variations in the general design are many. Parts may be hung from fixtures which in turn are suspended from an overhead monorail system which carries them through the complete heat treating cycle (harden, quench, draw, cool) in a vertical position.

To fit available space, continuous furnaces are frequently L-shaped or U-shaped in plan. The U-shape may also fit excellently into a desirable conveyer or other handling systems, since it loads and unloads within the same small area.

Moving Hearths – Figure 5 illustrates a popular type of furnace particularly suited for hardening small parts such as fasteners, lockwashers, nuts and screws. Such furnaces may be direct fired, electrically heated, or atmosphere controlled. Work is conveyed through the furnace at a controllable rate by slow forward motion of the hearth for a few inches followed by a quick return. The work goes with the hearth on its forward motion but is kept by inertia from backtracking.

Units have been built in various sizes ranging from those which are producing up to 600 to 1000 lb. of clean hardened work per hr., down to as little as 80 lb. They usually require no operator or only periodic filling of a hopper – even this, as well as the conveyance of finished work, can readily be mechanized if warranted by the tonnage being handled.

Moving hearths may be of other designs as well. One capable of carrying fairly heavy parts is a chain wherein each link has a flat upper surface, successive links joining at the pins so they present a continuous surface as they go through the furnace. To aid in circulation of hot gases, the links may be perforated.

Moving hearths are found in continuous furnaces of a wide variety of design and are adaptable to a wide variety of auxiliary equipment. As an example, Fig. 6 is a sketch of an automatic wash, draw and cool in which induction hardened

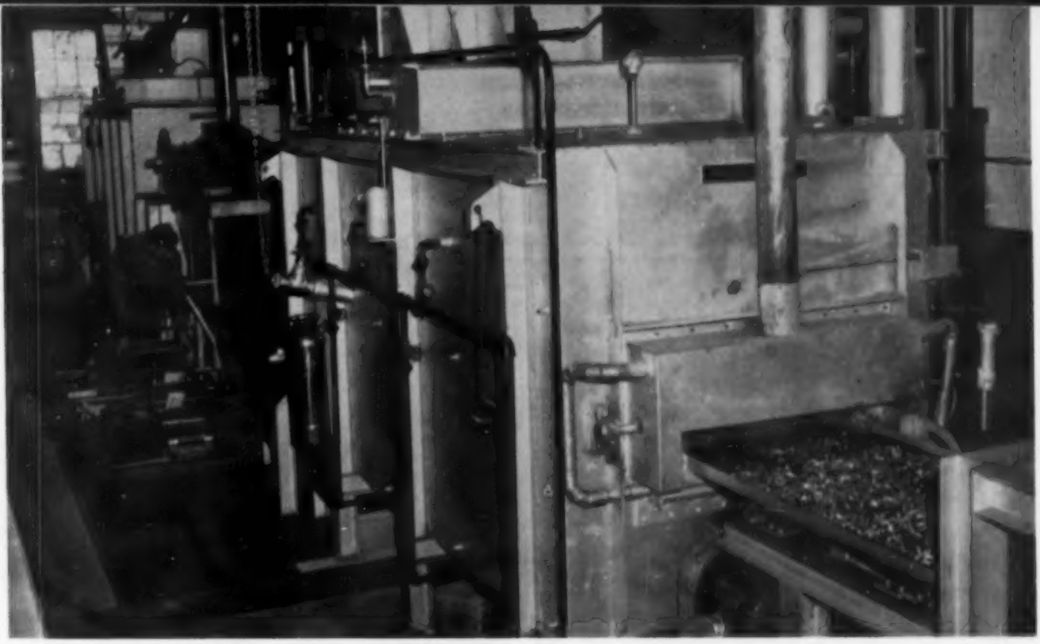


Fig. 5 – Shaker Hearths Are Convenient Devices for Handling Small Items. This line-up has hardening furnace, quench tank, and tempering furnace and delivers bolts bright and free from oxide. (Westinghouse Electric Corp.)

gears are processed. They come to the furnace on a continuous conveyer belt. After ten gears arrive and are placed on the carrier the pusher moves the carrier onto the continuous belt common to the washer, draw and air quench units. At the discharge end the gears are conveyed to the next operation.

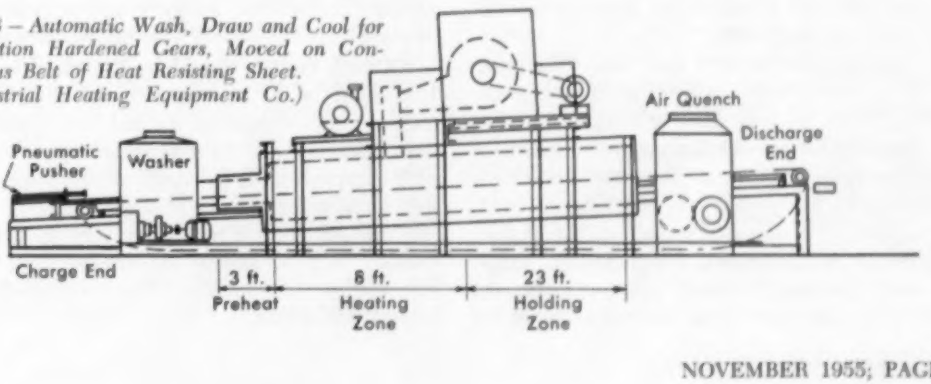
Rotating Spiral – Retort furnaces of this type are ordinarily used for the processing of small parts such as tappets or piston pins. The unit sketched in Fig. 7 consists of an alloy retort with an internal screw. The retort is heated externally by radiant tubes and prepared atmosphere comes in through the discharge end, and vents through a hood at the entrance. The furnace lends itself to automatic charging from hoppers by metering loader devices. Rotary tumbling effects uniform carburizing and a dribble quench makes for uniformly hardened pieces. Following passage through such a carburizing furnace and the quench tank the work proceeds through a wash and a draw.

Compared to the installation which this unit replaced there are many advantages, such as substantial production increase without increased labor cost, and improved quality both with respect to character, depth of case, and uniform hardness. Since the work was previously pack carburized, the elimination of dirt improved labor relations in the plant. The owner estimates that 50% over-all cost savings have been made over the previous type of carburizing equipment and operations.

To Mechanize or Not to Mechanize

The question of whether to mechanize or not to mechanize is one which can be correctly answered only by careful analysis and appraisal of the many factors involved. The possibilities may be narrowed by considering some of the

Fig. 6 – Automatic Wash, Draw and Cool for Induction Hardened Gears, Moved on Continuous Belt of Heat Resisting Sheet. (Industrial Heating Equipment Co.)



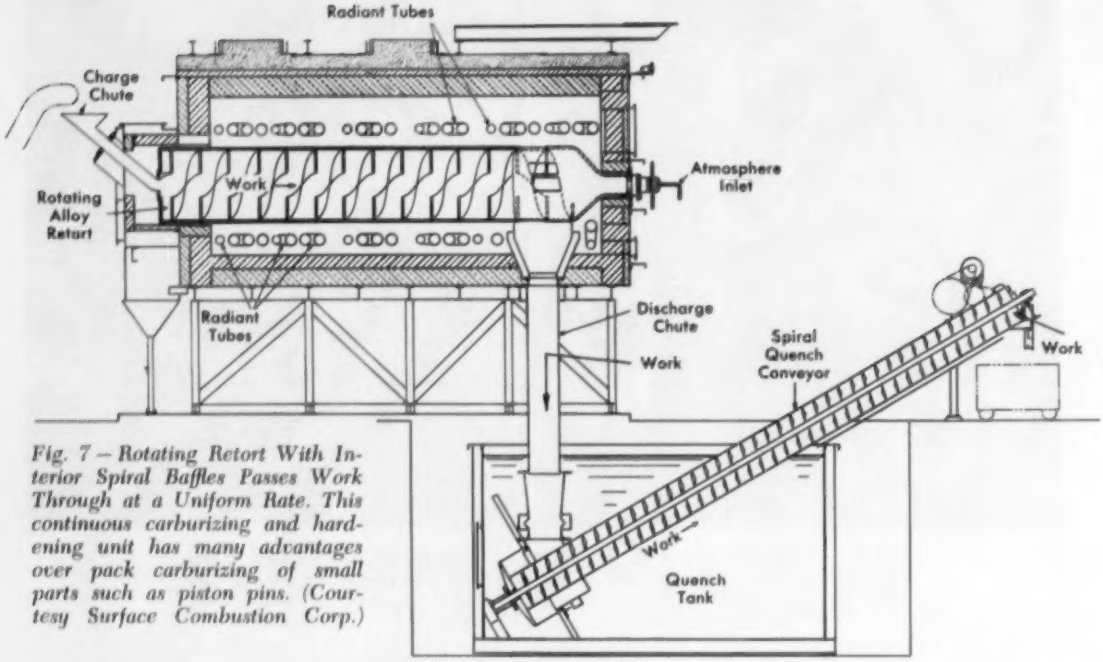


Fig. 7 – Rotating Retort With Interior Spiral Baffles Passes Work Through at a Uniform Rate. This continuous carburizing and hardening unit has many advantages over pack carburizing of small parts such as piston pins. (Courtesy Surface Combustion Corp.)

advantages and disadvantages of the various means of conveying parts through a furnace which have been illustrated in the foregoing.

1. *Part Pushes Part* – This method may permit the charging from a magazine or it may necessitate hand loading, shoveling, dumping or hand placing, depending on the shape of the part, the degree of finish and the process requirements and considerations such as nicking or distortion.

2. *The rotary hearth* usually entails hand loading and unloading through a single door by one operator using tongs; however, some rotary furnaces have been mechanized. Charging machines are necessary, anyway, for big stuff.

3. *Pusher trays* involve to a greater degree the same loading problems and considerations as mentioned above in "Part Pushes Part".

4. *Walking beams* may require hand loading. In some instances complete or partial mechanization may be applicable.

5. *Conveyer belt hearths* more often than not permit the use of hoppers from which the stock is properly fed by automatic loaders.

6. *Rotating Drums*–see 5 above.

The foregoing indicates that the first considerations in the problem of mechanized heat treatment involve the shape and weight of the part, the degree of finish, the distortion problem, and the metallurgical process involved. Another consideration is the volume of work or the quantity of identical parts that are to be processed or the volume of different parts which will require the same or closely similar heat treatment. This volume may vary widely; furnaces have been mechanized for as little as 100 lb. per hr. of little hydraulic pump vanes for automotive transmissions to upwards of 5 tons per hr. in steel mill processes.

In any event the normal volume of production should be that necessary to maintain the unit or line operating efficiently 16 to 20 hr. per day. The effect of mechanization on quality of product also must be thoroughly examined and evaluated. Scrap ratios should be carefully estimated and compared to rejects from manual performance.

Labor and other costs should be analyzed, manual versus mechanized. If a union contract exists, one must be sure that it will permit the full realization of the assumed or available labor saving. The ability, integrity and responsibility of the personnel should also be considered.

All such factors should be examined in hard cold light, and the engineers of the furnace industry are competent to aid and guide the inexperienced, and to supplement the thinking of the experienced, by virtue of the knowledge gained in solving many heat problems.

I can conclude in no better way than to reiterate: "A good look at an obsolete heat treat, followed by appropriate action, may easily uncover a pot of gold."

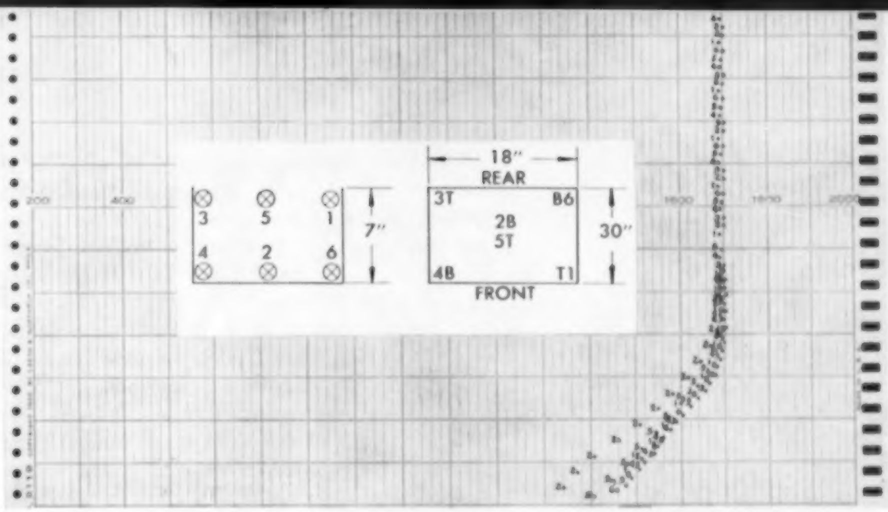


Fig. 1 – Uniformity of Temperature in Various Locations of a Batch Furnace Charge. The load was 500 lb. of pins, 1 in. diameter and 6 in. long

Mechanized Batch-Type Furnaces

*By MARTIN NEUMEYER**

Automation of batch-type furnaces is not yet as complete as with continuous furnaces, but batch furnaces offer better metallurgical control, adaptability and portability, and lower cost. (J general)

Since batch-type furnaces were developed first and have been in service for longer periods there might be the impression that they have become obsolete in contrast to the more recent developments in continuous furnaces. However, batch furnace development has not lagged behind. The modern batch furnace offers distinct advantages in metallurgical control, adaptability, portability and lower capital investment.

A batch-type furnace may be defined as furnace equipment that handles a given quantity of work through a complete process cycle in such a manner that it is not affected by other work in process. The quantity of work may range from the many tons handled by a car-bottom furnace to a few pounds treated in a basket submerged in a cyaniding bath. Mechanization of the equipment consists of replacing manpower with horsepower. The batch type of furnace provides better metallurgical control because it can be designed to heat the work rapidly to the processing temperature and hold it within very close limits. Since the work load is held stationary during the heating and soaking cycle, it is simple to provide for forced convec-

*Chief Research and Development Engineer, Industrial Furnace Div., Sunbeam Corp., Chicago.
Acknowledgment is hereby extended to the following members of the Industrial Heating Equipment Assoc. who manufacture these mechanized batch-type furnaces: Leeds & Northrup, Surface Combustion, Hevi Duty, Holcroft, Lindberg, Ipsen and Sunbeam.

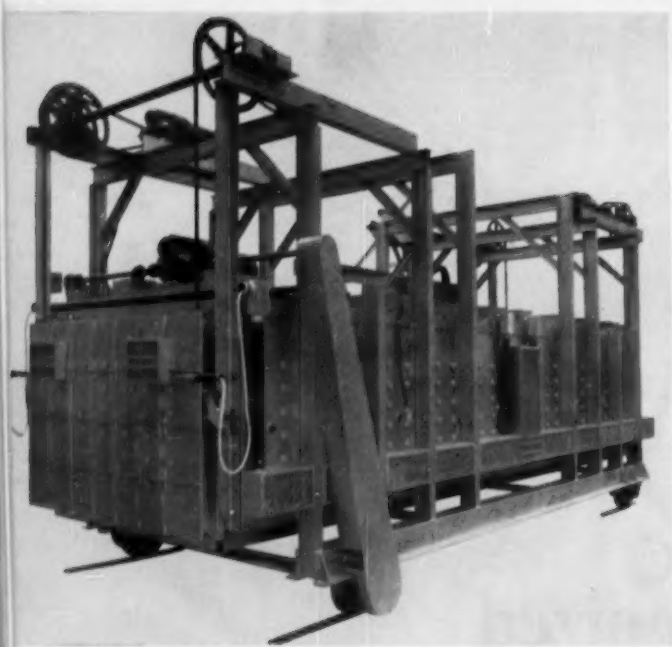


Fig. 2 – Double-Door Traveling Batch Furnace Can Be Moved to the Job

tion of the furnace atmosphere in a closed path of circulation.

Treatment of alloys requiring a specific cooling rate, such as cores for electrical applications, can be held to the closest limits of a controller. Batch-to-batch uniformity can be maintained to the point where differences cannot be detected with standard metallurgical quality control equipment. With modern methods of measuring carbon potential, the splendid atmosphere recirculation and temperature uniformity of batch equipment make practical the variation of carbon potential during a processing cycle to follow the most critical of metallurgical dictates.

In a continuous furnace, on the other hand, there must always be a temperature gradient through the furnace and it is difficult to provide positive closed paths of circulation of the furnace atmosphere through the work.

A good example of the uniformity of temperature obtainable in a batch furnace is illustrated in Fig. 1. The work load was 500 lb. of pins which were about 1 in. diameter by 6 in. long. The pins were stacked in layers and thermocouples were peened into the pins at the locations indicated on the sketch. The chart speed was increased at the top part of the chart to show the individual temperatures more clearly.

The load was processed for 4 hr. at 1700° F. and quenched under protective atmosphere. Carbon potential was held at 1.05% by a hot-wire analyzer type of carbon control equipment. Pieces of shim stock $0.005 \times 1 \times 6$ in. were located at 18 positions in the work load – three at the top front, three at the top center, and three at the top rear. The other nine pieces of shim stock were located at corresponding positions in the bottom of the work load. The carbon content of the shim stock ranged from 1.00 to 1.10% after treatment. Case depth measurements of pins located close to the shims varied from 0.033 to 0.035 in.

As an additional indication of the uniformity of processing in this type of furnace, a hardening heat was run for 30 min. at 1500° F. The carbon potential was set at 0.70% C, and 18 samples of oil hardening toolsteel were located in a 300-lb. load of No. 10 screws 1⅛ in. long. The samples were located in the same positions as previously described. Although this was a very dense load the hardness of samples varied only from C-62.5 to 64.

Adaptability of batch furnaces from load to load is limitless as to time at heat and controlled-atmosphere applications. Temperature ranges are limited only by the furnace design. It is not unusual to carburize, carbo-nitride and clean-harden successively in the same equipment. Normally a load following a carbo-nitriding cycle should be one that will not be adversely affected by small amounts of nitrogen remaining from the previous cycle. Processing temperatures at 1650° F. and higher will destroy traces of active nitrogen a few minutes after the ammonia is shut off.

Portability of equipment is another cost-saving factor often overlooked. Batch furnaces of the controlled-atmosphere "box" type, capable of heating 1000 lb. of work per hr. are available that require no pits or special foundations other than a floor capable of carrying the weight of the equipment. Plant rearrangement to suit production flow is thus greatly simplified. Floor space required for a given production capacity is at a minimum. A double-door traveling furnace used to heat retorts for critical aircraft applications is shown in Fig. 2. This furnace is brought to the job whenever and wherever needed.

Capital investment for batch equipment compares very favorably with that of continuous furnaces for a given production quantity. The "hearth rating" averages about double that of a continuous furnace.

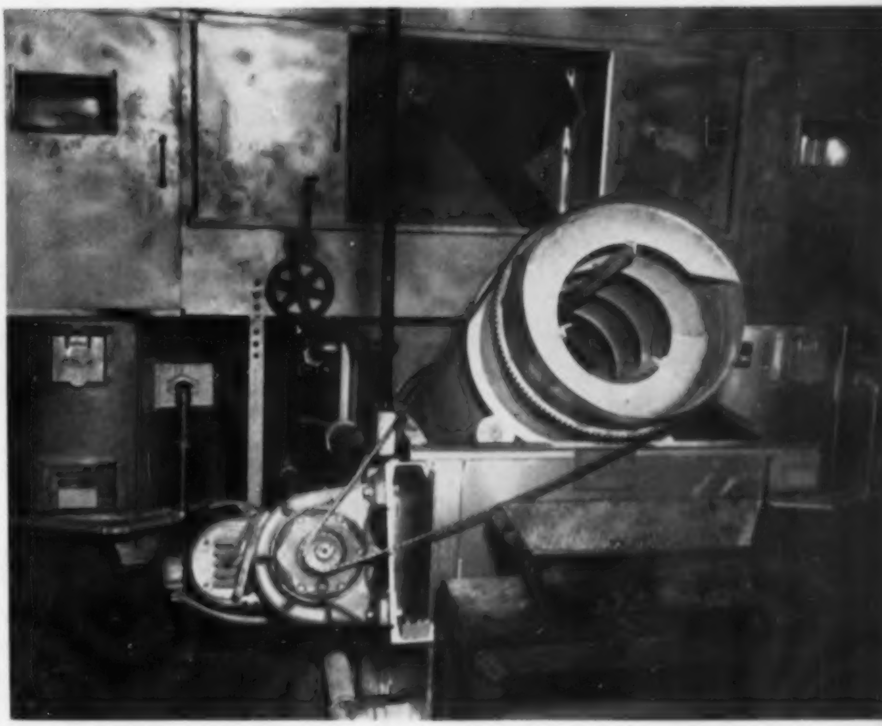


Fig. 3 – A Mechanized Version of a Cyanide Pot

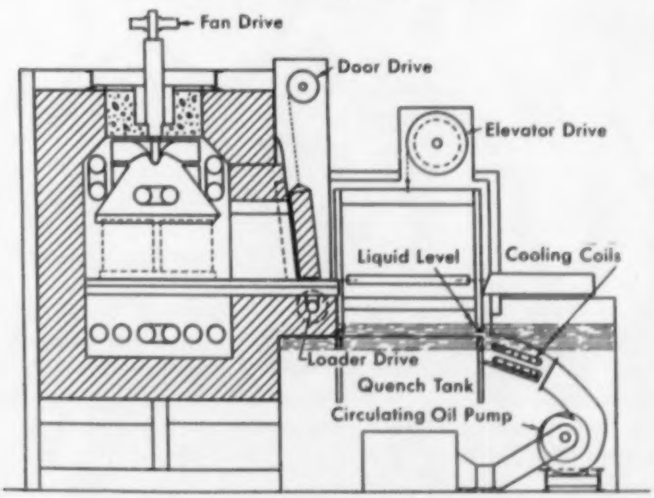
Where a heating rate of 50 lb. per sq. ft. of hearth area is considered high for a continuous furnace operating at 1600° F., the rate for batch equipment may exceed 100 lb. per sq. ft. Radiant tubes can be worked to double the heat output and still maintain the same heating efficiency.

Furnace manufacturers have developed a large variety of "standard" units. In effect, this means that a small portion of the engineering cost is reflected in the purchase price. Since standard equipment means duplicated units, the bugs that seem to be inherent in any equipment as first designed have been reduced to a minimum. Time consumed between placing an order for batch equipment and first operation date is shorter.

Mechanization

Batch furnaces have been developed to a high degree of mechanization and cover the entire field of heat treating. For example, a steel mill improved heat treat operations on armor plate castings by equipping a battery of direct-fired car-bottom furnaces with a single transfer car for loading and unloading. Considerable time and labor savings resulted from loading-unloading mechanization with minimum investment. Use of a single transfer is particularly applicable to the long heat treating cycles used for armor plate. Downtime is reduced – multiple units provide production when one furnace is down. Automatic cycle control of the furnaces provides uniformity of armor plate not possible with previous equipment and has practically eliminated rejects.

Fig. 4 – A Mechanized Controlled-Atmosphere Batch-Type Furnace



Mechanical handling of small parts is illustrated by the mechanized version of the cyanide pot shown in Fig. 3. The work is automatically dumped into a conveyer-equipped quench. The operator is shielded from the cyanide bath at all times.

Controlled-Atmosphere Furnaces – A furnace that has become popular in the past ten years and now

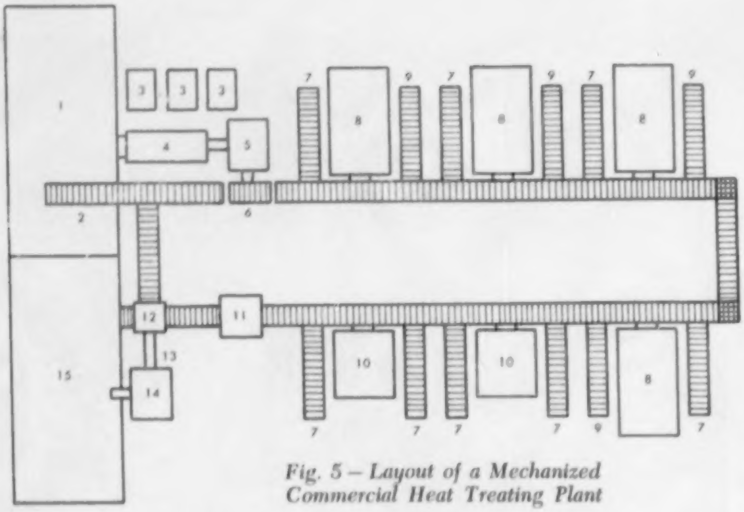


Fig. 5 – Layout of a Mechanized Commercial Heat Treating Plant

1. Receiving
2. Hand loading
3. Atmosphere generators
4. Three-stage wash
5. Weighing hopper
6. Weighing station
7. Storage station
8. Atmosphere batch furnace
9. Drain station
10. Recirculating draw furnace
11. Spray wash
12. Dumper
13. Elevator
14. Hopper
15. Shipping

constitutes a major percentage of the batch equipment being put into operation is the controlled-atmosphere batch furnace. It is sometimes called the "automatic box" furnace because the work is handled in boxes or rectangular baskets. Of particular interest is the high degree of labor-saving mechanization incorporated into these very efficient low-cost units. There are two kinds: "straight-through", in which the work is loaded at one end and unloaded at the other and "in-and-out", with only one door for loading and unloading.

A cross section through a typical in-and-out furnace is shown in Fig. 4. With this unit the operator preselects the atmosphere, temperature and time required for the charge, the type of quenching (or atmosphere), quenching time and the amount of oil agitation. He then pushes the charge into the furnace vestibule and punches the cycle start button. Automatically the inner furnace door opens, the work is pulled into the heating chamber, properly treated, pushed out onto the elevator in the vestibule and either lowered into the oil quench or allowed to cool in the atmosphere. The operator is required only to unload the work from the vestibule.

Savings with such furnaces are often sensational. In treating cutter blades for an electric shaver, the earlier method used was to harden 70 at a time in an open-fired box furnace. These blades were laid on a plate which had to be kept perfectly flat to prevent distortion. One man hardened a batch of 70 pieces every 15 min. or 280 pieces per hr. When the operation was transferred to a controlled-atmosphere batch furnace, 20,000 pieces were hardened per batch, using 45 min. of furnace time.

Commercial Heat Treaters

Several commercial heat treaters have installations in operation that are similar to the layout shown in Fig. 5. The work is dumped into a (pardon the term) "continuous" 3-stage rotary washer. The batch is weighed in the hopper, divided into furnace loads on a section of scale-mounted conveyer and moved to the furnace in which it is to be run. After treatment, if it was oil quenched, it is allowed to drain on a drain station and put through a spray washer. From the washer it is conveyed to the shipping room and loaded into the original containers.

In conclusion, heat treat schedules that cover a variety of alloys in assorted quantities and with a multitude of different heat treating cycles and processes require batch furnace equipment to obtain the necessary flexibility and metallurgical control. I hope that I haven't conveyed the impression that the batch furnace is the best choice for all applications. We know that many continuous furnaces are operating without the attention of a furnace operator. Batch furnace automation has not as yet been developed to that degree. The mechanical brain that would be required to sort loads, move them to the correct equipment and set the correct heat treat cycle seems at the moment to be economically unfeasible but is certainly worth striving for.

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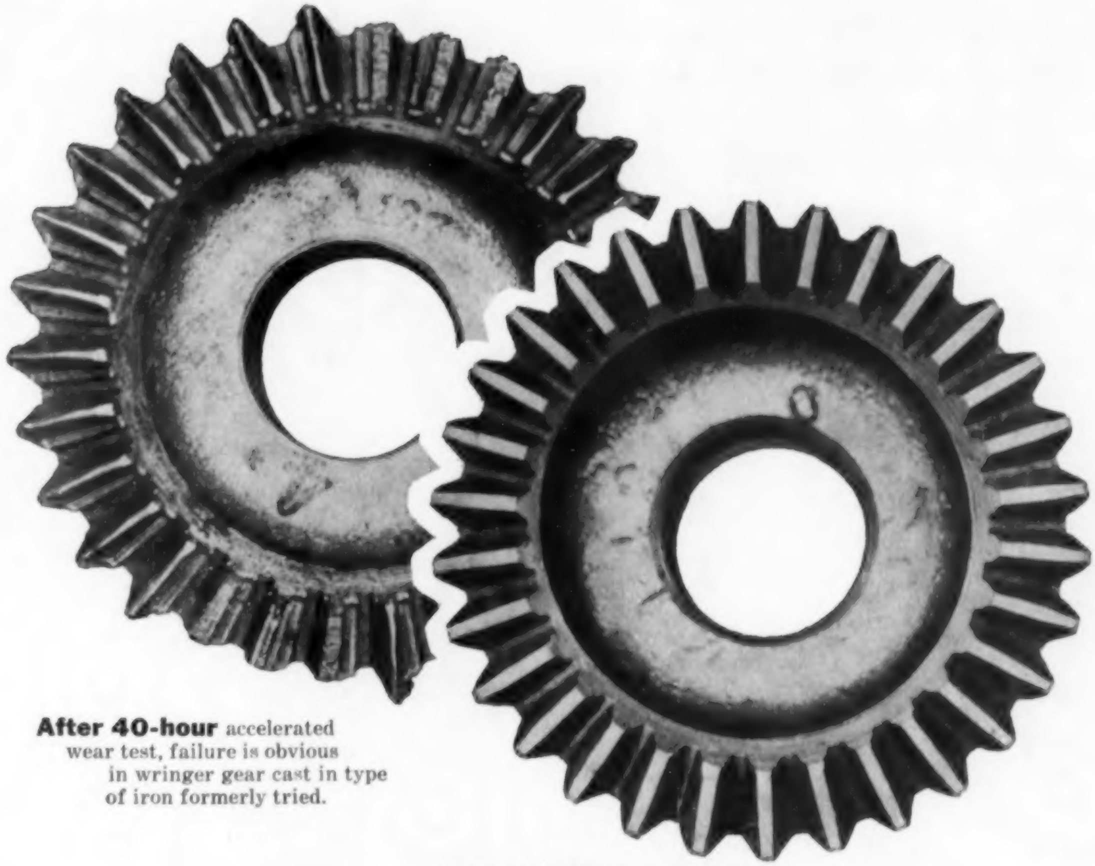

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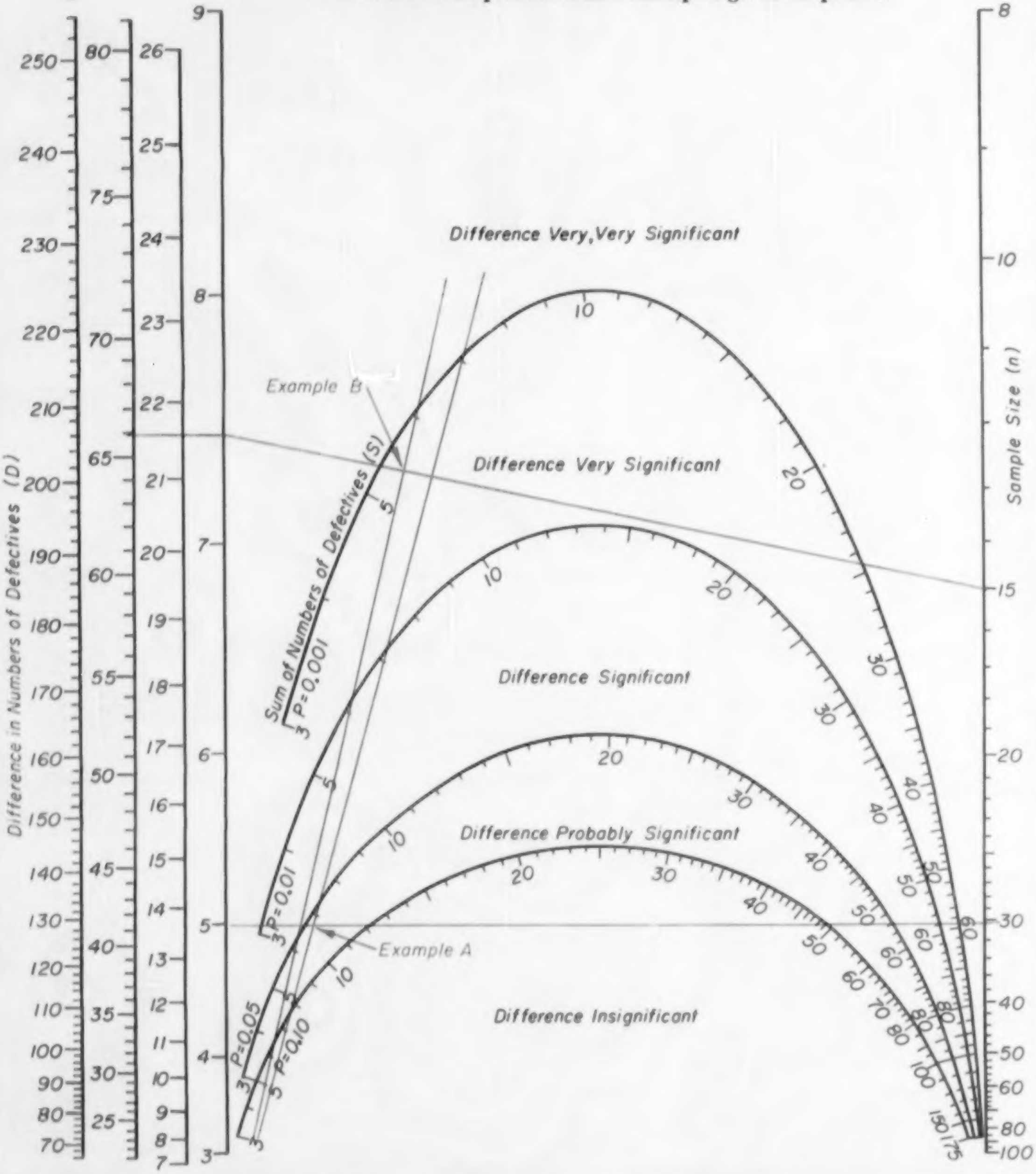
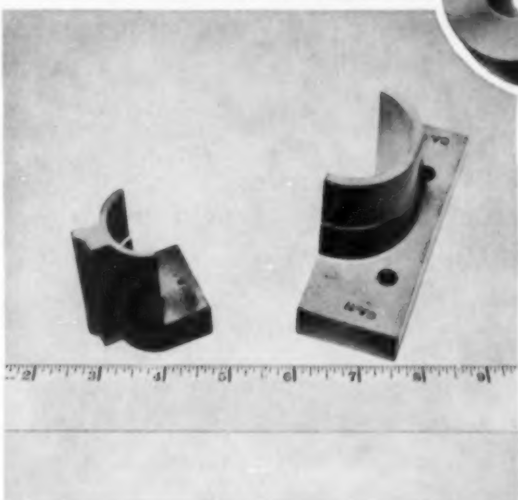
A Nomograph for Determining Significant Differences

By C. H. Li

Metallurgist, Tube Div.
Radio Corp. of America, Harrison, N.J.

A simple method for evaluating differences in test results and determining whether they are real or due to chance alone. Explanation and examples given on p. 105.





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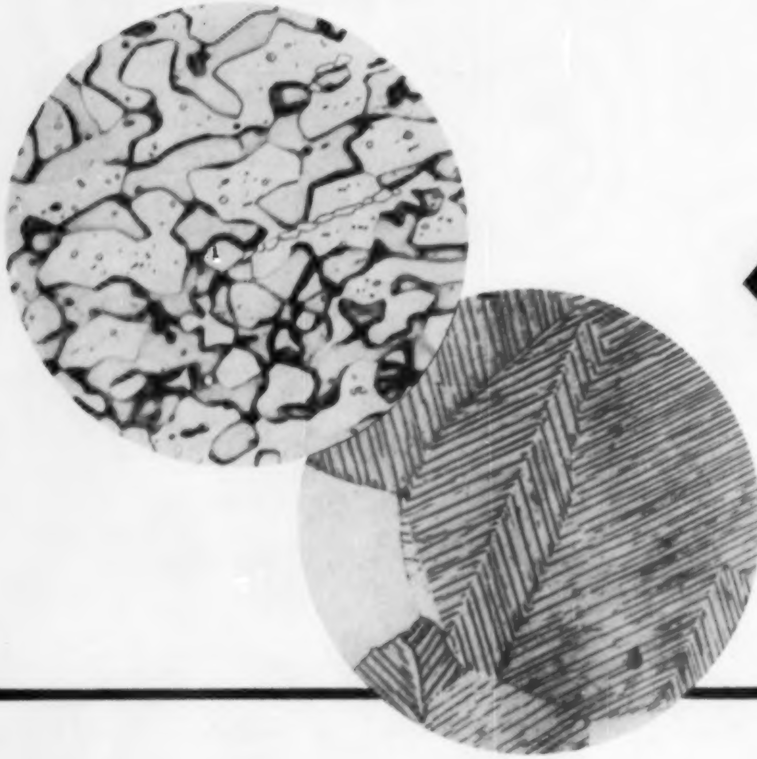

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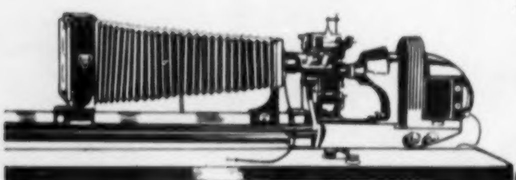

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Determining Significant Differences

*By C. H. Li**

When different results are obtained from identical tests on samples of equal size it is often difficult to tell whether the difference is significant or due to chance alone. Statistical techniques may be used to determine the significance but the calculations required are involved and time-consuming. With the nomograph on p. 104-B it is possible to tell quickly whether or not the differences are real.

The nomograph covers a range of sample sizes from 8 to 100,000 with four scales 8 to 100, 80 to 1000, 800 to 10,000 and 8000 to 100,000. It should be used only when comparing samples of equal or nearly equal size. The procedure is as follows:

1. Find the difference between the numbers of defectives ($D = d_2 - d_1$).
2. Draw a straight line connecting the sample size ($n_1 = n_2$) on the n-scale to the point representing the difference between the numbers of defectives ($D = d_2 - d_1$) on the D-scale. The n-scale is numbered for the smallest range, 8 to 100. For larger samples it should be multiplied by 10, 100 or 1000 depending upon the range required. The corresponding D-scale should be used, but the desired point must be projected horizontally onto the D-scale for sample sizes from 8 to 100.
3. Find the sum of the numbers of defectives ($S = d_2 + d_1$).
4. Connect the four points $S = d_2 + d_1$ on the four S-scales with a line. The values on the S-scales are for sample sizes from 8 to 100; for the three higher ranges multiply by 10, 100 or 1000.
5. Find the point of intersection of the lines; the region in which this point lies defines the significance.

The terms "probably significant", "significant", "very significant", and "very, very significant" are used to designate differences between test results for which the probabilities of occurrence due to chance alone are less than one in 10, 20, 100 or 1000, respectively. Conclusions obtained from the nomograph, therefore, would be wrong less than one time in 10, 20, 100 or 1000, respectively.

Because "acceptable" and "defective" are attributes, they may be interchanged in using the nomograph and will yield the same probability statement. This change is desirable when S is greater than the sample size because the left portions of the S-scales are more accurate than the right portions. The use of the nomograph is best illustrated by the following examples.

Example A

Situation — A certain company has been purchasing semifinished products for processing from Vendor X exclusively. Vendor Y claims that his semifinished products, although slightly more expensive than those of Vendor X, are much better in performance . Test results show that of 30 sample units from Vendor X, 6 (or 20%) are defective; of 30 sample units from Vendor Y, 1 (or 3.3%) does not meet the specification.

Question — Does the difference between the numbers of defectives in the two samples constitute sufficient evidence to warrant the purchase of the semifinished products from Vendor Y at slightly higher cost?

Method of Analysis — The number of defectives is 6 for sample X and 1 for sample Y; their difference and sum are 5 and 7, respectively. A line is drawn, therefore, connecting Point 30 on the n-scale with Point 5 on the D-scale. Another line connecting the 7's on the four S-scales intersects this line in the area marked "difference probably significant". Hence, the difference is significant at a level between 0.10 and 0.05, or the probability of such a difference occurring due to chance alone is less than one time in ten but greater than one time in 20.

Conclusion — The observed difference between the numbers of defectives in the two samples could happen occasionally due to chance alone. If the semifinished products from Vendor Y are better than those from Vendor X, therefore, more evidence will be needed for proof. However, it is quite probable that examination of a larger sample from each of the two vendors will show the products of Vendor Y to be distinctly better than those of Vendor X. On the basis of these test results alone, it is inadvisable to change suppliers of the semifinished products.

Example B

Situation — An inspector finds that of 1500 units of a semifinished product processed in period Y, 265 (or 17.7%) are defective. From a more recent lot of 1500 units manufactured in period X, 331 (or 22.1%) are defective.

Question — Could the sudden increase in number of defectives in the manufactured products be due solely to chance variation?

Method of Analysis — A straight line is drawn connecting 66 on the D-scale with 1500 on the n-scale. Another line joining the points representing 596 (the sum of the numbers of defectives) on the S-scale intersects this line in the region of very significant difference. Hence, the difference is significant at a level between 0.01 and 0.001, or the conclusion reached on the basis of the results would be correct 99.0 to 99.9% of the time.

Conclusion — The very significant difference between the numbers of defectives in the two manufacturing periods X and Y shows that the manufacturing process was out of control in period X as compared to period Y. It is necessary, therefore, to seek assignable causes for the lack of control and to adopt corrective measures quickly.

In the examples given above, the difference between the percentage of defectives in the samples X and Y was much greater in the first example than in the second. Because of the varying sample sizes, however, the difference between the samples was probably significant in the first, but very significant in the second. These examples illustrate how easily erroneous conclusions may be reached if the use of statistical techniques is neglected. It can also be seen that comparative test results expressed in terms of per cent defectives may be very misleading if the actual sample size is not given.

* Metallurgist, Tube Div., Radio Corp. of America, Harrison, N. J.

Molten Baths and Mechanisms

*By L. B. ROSSEAU**

Molten baths may be lead, salt, or oil. Their peculiar requirements impose certain restrictions on the design of handling mechanisms, but many types of equipment have been developed for all sorts of heat treating operations. Some representative examples are described. (J2)

During the last two decades the use of molten baths for heat treatment has grown rapidly due not only to improved designs and performance, to new and cheaper heating mediums, but also because many new fields of application have been intensely studied. Three mediums are now commercially used for large-scale applications, namely, lead, salts and oil. Their characteristics are listed in Table I.

Molten baths of any composition have common characteristics influencing their selection for industrial uses. These are:

High rate of heat transfer, secured entirely by conduction through the surface of the object. Figure 1 shows in colored lines the rate of heating in air, in 50-50 NaCl-KCl salt, and in lead of the center of a 1-in. round of S.A.E. 1040 steel, 3 in. long. Compare also the quenching power of three commonly used mediums, water at 70° F., oil at 120° F., and salt at 400° F., measured at the center of the same specimens when quenched from 1550° F. in baths with identical agitation.

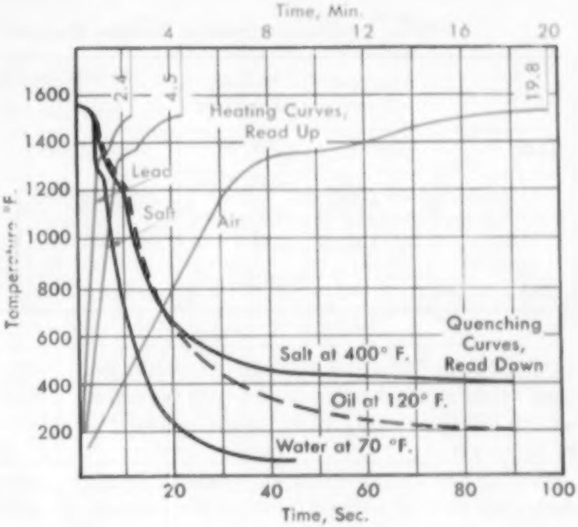
Hot oil has considerably poorer cooling power when at the same temperature as a salt bath. Therefore, while it is used for martempering, the work must be of steel of greater hardenability than when quenched in a salt bath. Oil is generally used for baths operating below about 400° F.

Uniformity in Temperature – The high heat content per unit volume of a molten bath and its internal circulation resulting from either thermal flow or electrodynamic effects result in a nearly perfect pattern of temperature distribution throughout the working volume, even in very large installations. For example, certification tests for aircraft requirements of two different applications are as follows:

In equipment for martempering flap tracks and landing gear components, consisting of a furnace 4 ft. square and 16 ft. deep, operating

*Vice-President, Ajax Electric Co., Philadelphia.

Fig. 1 – Colored Lines Show Rate of Heating in Lead, Salt and Air, and Time for Center of a 1-In. Round to Reach Bath Temperature (1500° F.) Black lines show quenching rates of hot salt, warm oil and cool water



at 1600° F., the maximum deviation at 16 survey points top to bottom and side to side was 10° F. In another furnace for solution treatment of aluminum alloys whose dimensions were 13 ft. long, 3 ft. wide and 6 ft. deep the maximum deviation at 1000° F. of 25 equally distributed checking points was 70° F.

Absence of Atmosphere – Being fully submerged, the work is entirely out of contact with air; no protective atmosphere is required.

Limitations – Since the heating medium is a liquid, the shape or configuration of the work is limited to parts which will not cause high economic loss by dragout.

A molten bath requires a liquid-tight container; therefore it can only be entered from the top. The heat loss from the hot surface corresponds very closely to black-body conditions, especially in the higher temperature ranges. These two facts necessitate handling mechanisms which differ in many respects from conventional designs. Many types have been developed to handle the work through all the steps involved and are comparable in all respects to those available with atmosphere furnaces.

Case Histories of Handling Mechanisms

The immersed electrode for heating fused salts, the built-up ceramic container for the higher temperatures, and the immersed, gas-heated tube for the lower temperature applications have removed the limitations in size and capacity which previously existed. Adequate hoods and ventilation have solved the problem of heat lost from the bath's surface – at least as far as comfort to operators is concerned.

Many installations consist entirely of a series of molten baths. Others combine conventional heating equipment and molten baths, with or without cleaning tanks. A few typical installations of both types are illustrated in the following case histories.

Neutral Hardening – Equipment photographed in Fig. 2 is for complete hardening of perforated cartridge cases made of S.A.E. 1030 steel. No scale or decarburization is permitted and distortion must be within the correction limits of a press sizing operation. High and uniform physical properties are also required. The cases are 24 in. long and weigh 12 lb. each. Capacity of the equipment is 330 cases per hour and the heat treatment cycle requires 23 min. Labor is two men, one loader and one unloader at the other end of the 85-ft. line. An interesting feature of the transfer mechanism is the fact that all of it is exterior to the furnace and operates substantially at ambient temperature; thus, no heat resisting alloys are required other than a small rod supporting the piece itself and weighing a fraction of a pound.

Results: no failure in firing tests to date.

Similar equipment is used in a line for a more complicated set of treatments for smaller steel cartridge cases requiring annealing at the mouth. In this the cycle is only 21.5 min. First the cases, mouth down, are austenitized, then quenched with internal jets (being washed at the same time). Out of the quench they pass over gas flames for drying. Then the mouths are immersed to proper depth in an annealing bath. The rest of the line is a long tank of hot salt for drawing, and two short ones, the first for washing and the second for rinsing.

Carburizing – Figure 3 is a schematic arrangement for case hardening. Each carrier contains ten small forged crankshafts, 3 lb. each, hung vertically. They are to be carburized to a depth of 0.040 in. and hardened to C-60 or higher. Distortion is minimized to a point where the heat treated shaft can be straightened without cracking. The carburizing bath operates at 1750° F. and the entire cycle requires 2 hr. 40

Table I – Characteristics of Heating Mediums

Medium	Melting Point	Weight per Cu. Ft.	Temperature Range	
			For Heating	For Cooling
Lead	620° F.	660 lb.	650 to 1650	—
Salts				
Chlorides	1550 and up	180	1650 to 2350	—
Chlorides	1000 and up	100 to 140	1100 to 1650	1300 to 1000
Nitrates	300 and up	115	325 to 1150	1000 to 350
Caustic	—	110	650 to 1250	1000 to 650
Oil	—	55	70 to 600	400 to 200

min. One man can put through 65 cranks per hour. Loading and unloading, it will be noted, are at the same end. Floor space required is 44 ft. by 9 ft.

Deeper cases – say 0.050 in. – require longer cycles, up to 4 hr. This would cut the capacity of such a line as in Fig. 3 unless the salt bath were correspondingly lengthened.

Martempering lines are similar to the one shown in Fig. 3. A typical one to harden components of an automobile transmission consists of the following items in order: 1. Loading station. 2. Alkali wash tank. 3. Spray rinse. 4. Dry. 5. Austenitizing bath. 6. Hot quench bath. 7. Air cool. 8. Draw bath. 9. Air cool. 10. Wash tank. 11. Hot water rinse. 12. Unloading station.

Total floor space required is 70 ft. long by 18 ft. wide. The capacity is 300 pieces per hr., and time cycle is 3 hr. Total connected load is 210 kw. Labor required is one loader and one unloader.

Such equipment hardens the work to such strict dimensional limits that the transmission components can be finish machined prior to heat treatment. Parts are 1.5 in. maximum diameter, 14 in. long, and weight about 2 lb. each.

Annealing and Cleaning – Automatic transmissions are almost standard equipment in today's automobile. Their design calls for extremely

Fig. 2 – Mechanized Salt Bath Line for Hardening Perforated Steel Cartridge Cases. Courtesy Ajax Electric Co.

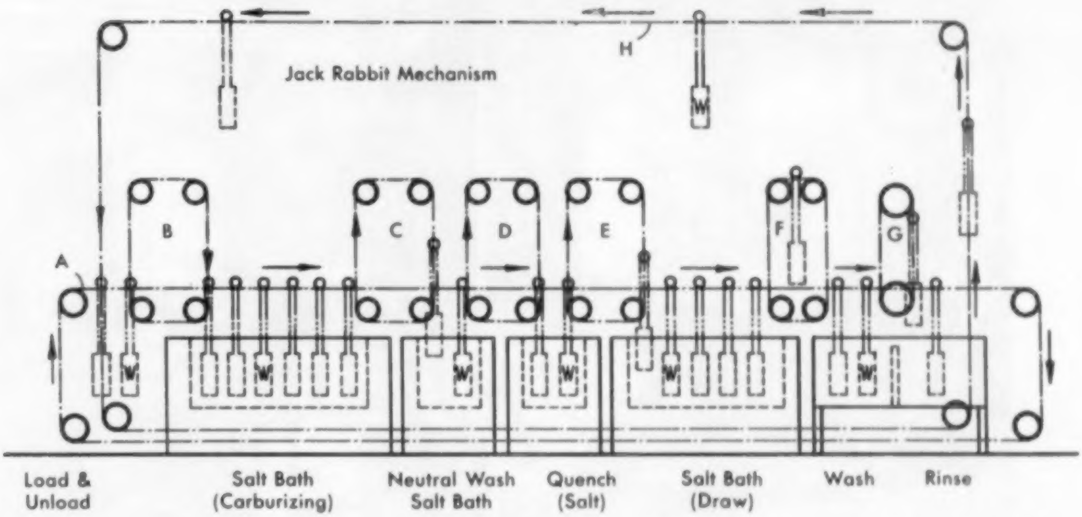
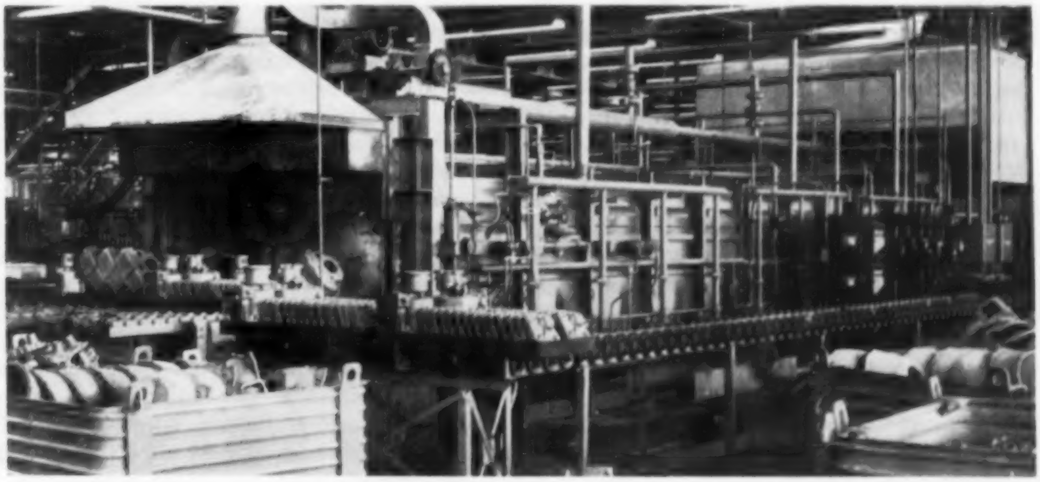


Fig. 3 – Schematic Arrangement of Mechanized Equipment for Carburizing Small Crankshafts

close tolerances between components. Satisfactory performance requires cleanliness in the assembled unit; therefore, scale, sand, or similar foreign matter *must* be entirely eliminated. Many of the parts are cast iron, and the problem involved was to anneal castings after the normal foundry shot-blast, remove all scale resulting from this anneal, remove any core sand which might remain on the casting – all at the rate of 10,000 lb. per hr. This was accomplished by a line-up of conventional annealing furnaces (atmosphere) and molten salt descaling.

This mechanism differs from those previously discussed in that it consists of a sequence of intermittent motions instead of continuous. Furthermore, trays are used instead of fixtures and they are returned from the unloading end by a conventional gravity roller conveyer. A hot basketful emerging from the long annealing furnace is quenched in a bath of hot salt which simultaneously descales the work. This quench is an electrode type of salt bath furnace containing a proprietary descaling salt based on sodium hydroxide. Final units in the line are a draining and cooling station, a washing bath, an acid bath, a final wash, and then a dip into

Fig. 4 – Charging End of Furnace for Annealing Transmission Castings. It is followed by line-up of hot salt quenching and cleaning baths. Courtesy Holcroft & Co.



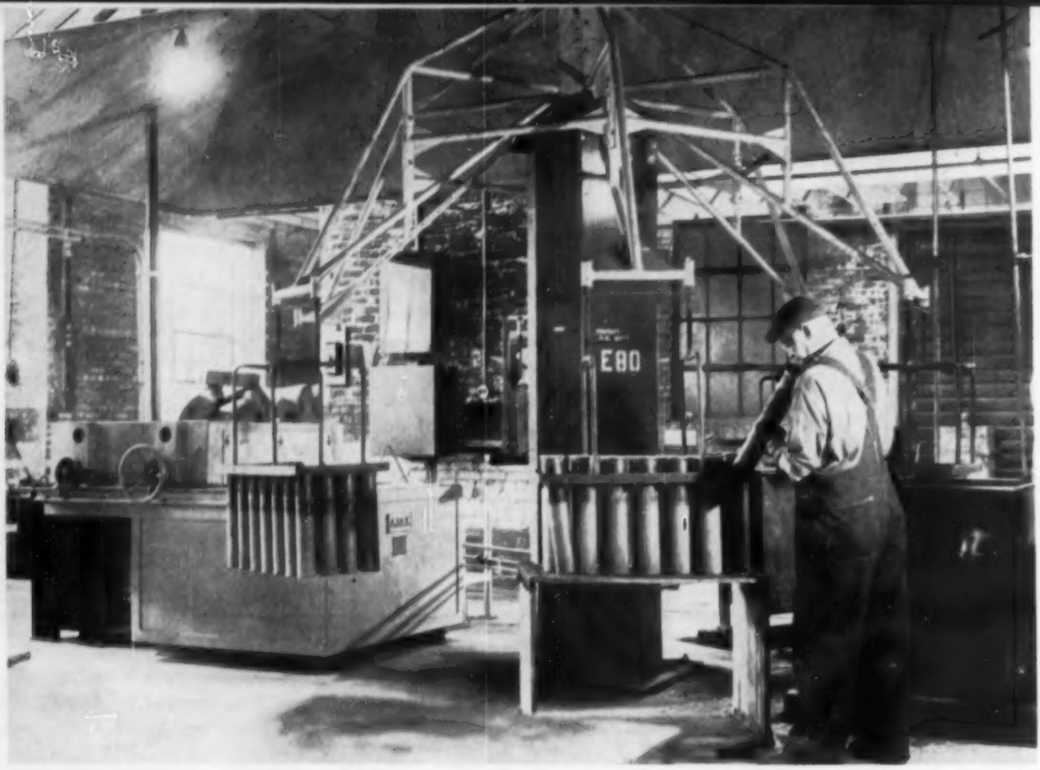


Fig. 5 – Merry-Go-Round for Taper Anneal of Brass Cartridge Cases

soluble oil. Floor space occupied is approximately 80 ft. long, 20 ft. wide and 12 ft. high. The installation is illustrated in Fig. 4.

A number of similar installations, with and without the annealing furnace, and with units heated either by gas or electricity are in service.

Descaling of Stainless Strip – Stainless steel of the A.I.S.I. 300 or 400 series acquires a very tough adhering oxide during annealing. It is commonly descaled by one of several proprietary processes, all of which utilize molten salts. A continuous operation – annealing, descaling and cleaning – is almost mandatory; the strip acts as its own conveyer, but pinch rolls, drive rolls, tension rolls and coilers are necessary. Such an installation can handle strip up to 52 in. wide with thickness ranging from 0.018 to 0.095 in. The capacity of such a unit would be about 18,700 lb. per hr. when operating at 950° F. The length of the descaling bath is 35 ft.

Annealing of Brass – A salt bath is inherently well suited to selective heating of such things as brass cartridge cases, which are generally subjected to two such operations – mouth and taper anneals. Since large numbers are involved, mechanization is indicated. The treatment, however, is simple: immersion to a proper depth for a definite time at a definite temperature. This lends itself perfectly to a simple mechanism known as a merry-go-round. This provides a compact arrangement which is fully automatic, and can produce very substantial tonnage. Figure 5 illustrates such a unit. Twenty-eight cases fill the fixture and since the time cycle is short, 20 to 25 batches can go through each hour. Four stations at 90° to the central hoist are: 1. Load (and unload). 2. Salt bath heated by immersed electrodes. 3 Quench bath. 4. Wash tank.

Conclusion

This paper is primarily limited to those applications wherein heat is transfered to work at rapid rates under control, with substantially no effect on its surface. It also includes similar heat transfer equipment to make certain specific changes on the surface and adjacent layer of the work under controlled conditions. It does not cover those applications where it is intended to coat the surface with a layer of different material, such as tinning, galvanizing, leading, or aluminizing.

Due to space and time limitations, only a few representative examples of mechanization of molten baths could be given. Many others are available and cover such operations as heating for forging, cyanide hardening, austempering, patenting and brazing. Proven equipment for all such processes is available from many equipment manufacturers, and its selection is largely dependent on the economics involved.

Combustion Systems in Steel Plants

*By FRED S. BLOOM**

Combustion on a grand scale is common in heating furnaces in steel plants. Combustion systems, however, are quite similar to those existing in other industrial furnaces except for methods of controlling the fuel-air ratios at the burners. (F 21)

THE method of burning fuel has received more attention by engineers and operators in steel plants than in most other industries because of the fact that such enormous quantities of fuel are consumed. Design of the combustion systems is further influenced by the fact that the steel plant produces large quantities of auxiliary fuel such as coke oven gas, blast furnace gas, and liquid tar. Thus, one fuel may be supplemented or replaced by another at short notice due to peculiarities in the plant operation. Thus, we not only have a problem of using by-product fuels, but we have the problem of quick change.

The by-product fuels of the steel plant are invariably dirty. Coke oven gas is only partly cleaned of dust and also carries with it tar which gums up the valves unless considerable power is used to operate them. Thus, it is impossible to use a diaphragm type of regulator on a coke oven gas system such as would work beautifully on city gas or natural gas. Likewise, the volumes of gases which must be handled are out of proportion to those used by other industries. As an example, the fuel input to the blast furnace stove through one burner can develop as much as 200,000,000 Btu. per hr! Heat put into the openhearth furnace through a single burner is 100,000,000 Btu. per hr.

These unique factors have led to the development of a unique combustion system for steel plants. It costs more to operate and it costs more to install, but the monthly fuel bill is so large that any device which makes for economical use is justified.

A Definition – Before progressing too far, we need a definition. What is a combustion system? Let us agree that the term covers:

1. The burner – (whether pre-mix, nozzle mix, or other).
2. Control of fuel input.
3. Control of combustion air (that is, the fuel-air ratio).
4. The air supply (whether cold, preheated by recuperation or by regeneration).
5. Control of air leakage into the furnace (that is, the furnace pressure).

The purpose of *any* combustion system should be stated. Primarily it is to provide heat, but the problem is not always solved when devices for complete oxidation of the fuel are installed. Once the heat is produced, it must be transferred to the work. Uniformity of heat generation and of temperature distribution are still other problems. Thus, each combustion system must be designed to accomplish a specific result. One must develop high temperatures and rapid heat transfer rates such as in the openhearth furnace. Another demands uniformity of temperature, as in soaking pits.

It would take us too far afield to discuss the various possibilities indicated by variations in the five items listed above, so we can say immediately that the desire to devise a control by a single valve of both fuel and air has led to

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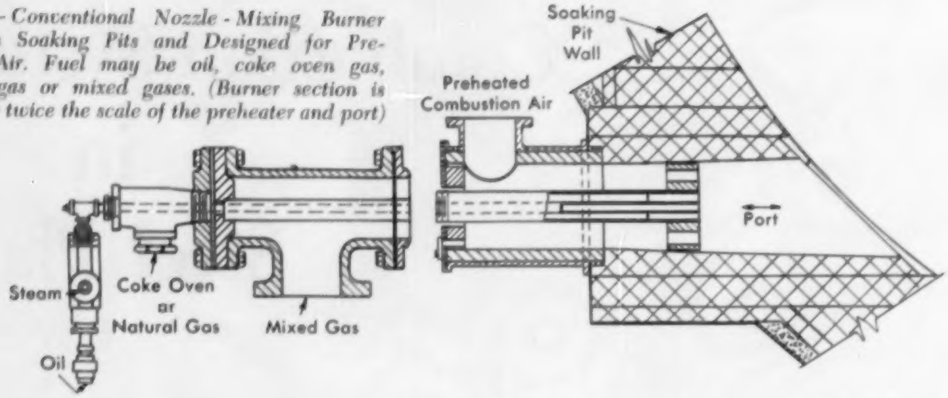
Fig. 1 — Conventional Nozzle-Mixing Burner Used on Soaking Pits and Designed for Preheated Air. Fuel may be oil, coke oven gas, natural gas or mixed gases. (Burner section is drawn to twice the scale of the preheater and port)



the inspirator burner (Fig. 1) wherein a stream of fuel at high pressure drags in the necessary air for combustion.

Mixing machines accomplish this same purpose with a pre-mix burner system. Again, the same single-valve control for a nozzle-mix burner system is obtained with a pressure regulator for balancing the fuel-air ratio, or with a power-driven regulator. Consequently, combustion systems in steel plants may be characterized by the nature of the means used for controlling the fuel-air ratio (item 3 in the above list of functions). All other functions are controlled in a manner similar to those throughout other American industries.

Improvements in steel plant combustion systems started with the development of an accurate regulator for fuel-air ratio. Such a regulator demanded the measurement of fuel and air. These measurements enabled the combustion engineer to spot the good and bad features of his combustion system. This was the necessary prerequisite to the design of a better system.

Specific Instances

Blast furnace stoves, as are well known, burn large volumes of blast furnace gas — none too clean and of comparatively low heat value — in a large combustion well as high as 95 ft. The hot products of combustion then come down through the checker system to heat it. Periodically the flame is cut off and air blows through in the opposite direction, out the hot blast main and into the furnace.

The combustion system consists of a single nozzle-mix burner for each stove, complete with fan and fuel-air ratio regulator. Large burners need 35,000 cu.ft. per min. of combustion air; fans are driven by 50-hp. motors. One peculiarity is that temperature is automatically controlled without altering the fuel input — fuel consumption must equal production of top gas by the furnace; there are no storage facilities. The flow of the air is therefore increased to prevent excessive temperatures in the checker work. This is one of the original applications of the "tempered flame" burner principle.

Openhearth furnaces also present unique problems. The combustion system must transfer heat to the bath at the maximum rate short of melting the roof. Thus it depends upon the characteristics of the fuel (whether producer gas, natural gas, or fuel oil) and the type of flame. It also depends on the efficiency of the regenerators — the hotter the combustion air the higher the furnace temperature and the greater the production. Furthermore, the furnace port is the burner; here, fuel meets air and combustion starts. The flame direction and the degree of mixing of fuel and air are determined by the port and fuel burner design. Accurate shape of the port is hard to maintain because it functions as burner port only half of the time. The other half it is the exhaust.

Under these circumstances it is easy to see why it is money in pocket to use a variety of accurate recording and control instruments on each furnace. These include (*a*) automatic furnace reversal, whose principal function is to start, in proper sequence, a train of many operating units required to reverse the system in minimum time; (*b*) automatic control of fuel input, air input and furnace pressure; (*c*) recorders for roof temperature and warning signals against overheating, and (*d*) numerous meters and recorders for all flows and pressures.

Soaking pits form a transition between the batch operations in the openhearth and the fairly continuous demands of the blooming mill. Con-

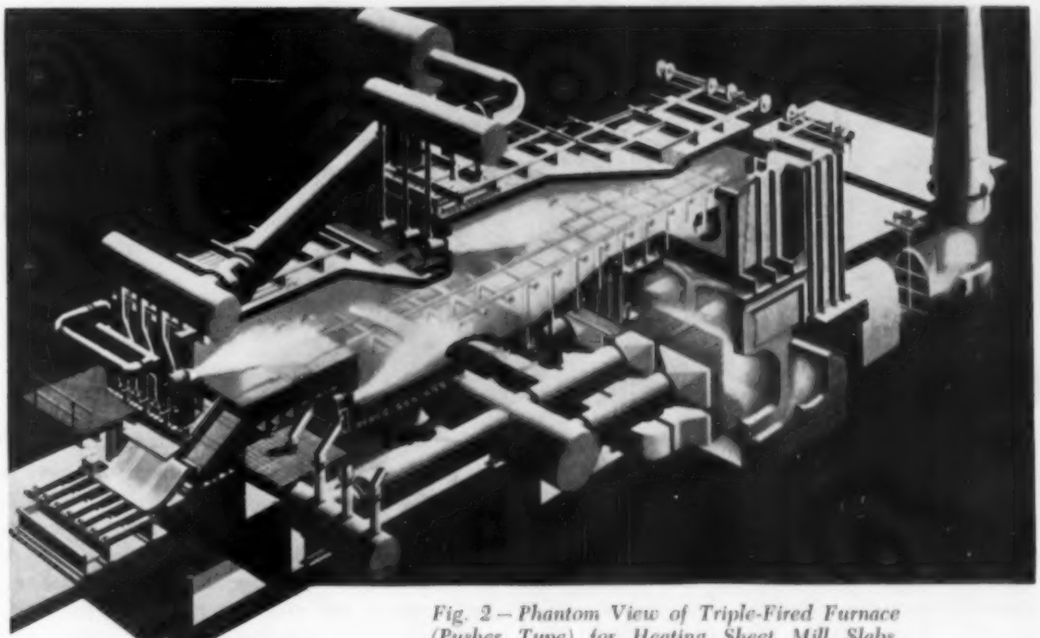


Fig. 2 — Phantom View of Triple-Fired Furnace (Pusher Type) for Heating Sheet Mill Slabs. Flues at entrance (right) end lead to underground recuperators for preheating combustion air

sequently, they are a storage yard or reservoir in addition to their main purpose — namely, to bring the ingots to a uniform temperature, surface to center and ingot to ingot. The desire to obtain a uniform temperature has evolved many designs of furnaces and combustion systems.

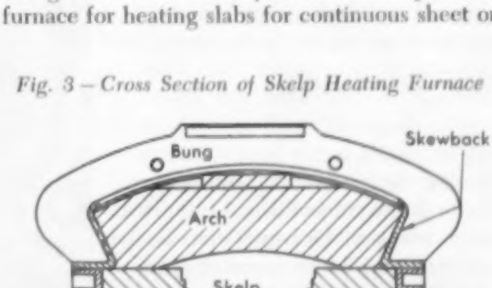
One important design is a rectangular pit fired by burners at top of one end wall and gases drawn off through ports in the bottom of the same wall. Hot exhaust goes through refractory recuperators (sometimes followed by metallic tubular heat interchangers) and thence to stock. Combustion air, flowing counterclockwise to the waste gases, goes through a Venturi jet pump and a hot header before being apportioned to the various burners. Other designs utilize recuperators on either end and reverse the flow of gas periodically, as is done in the standard open-hearth furnace. Some operators prefer pits which are circular in plan, fired tangentially at several places around the circumference, hoping thereby to get better uniformity in temperature in a heavily loaded charge of massive ingots.

The combustion system, regardless of how the burners are arranged, is approximately the same — namely; (*a*) a recuperator furnishes preheated air; (*b*) a nozzle-mix burner uses oil or gas, as shown in Fig. 1; (*c*) temperature control regulates the fuel input; (*d*) air is controlled by a fuel-air ratio regulator in accordance with measured fuel supply and (*e*) furnace pressure is automatically controlled.

Reheating furnaces take various forms depending upon the product and type of material to be heated. Most commonly they are of the pusher type, where the billets push each other through the furnace on stationary, water-cooled rails.

Figure 2 is a cut-away view of a triple-fired furnace for heating slabs for continuous sheet or

Fig. 3 — Cross Section of Skelp Heating Furnace



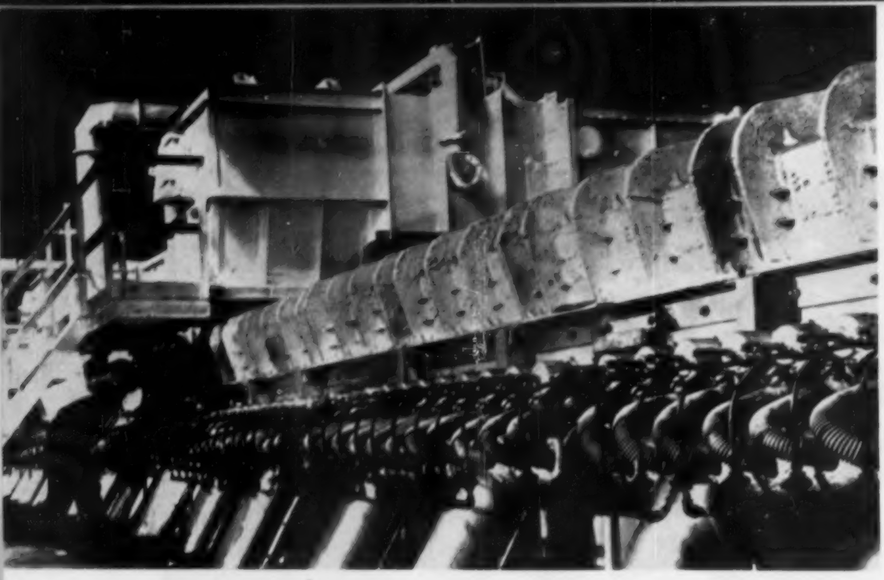


Fig. 4 – Side View of High-Speed Heating Furnace for Skelp Shows an Almost Continuous Series of Burners

strip mills. Movement of material is from the far end to the hot end at left. The pusher furnace is universally accepted whenever material is of suitable shape and weight. Other materials, such as round billets, slugs, or odd shapes, are generally conveyed through the furnace on a movable hearth. Burners obviously should be designed to produce long, hot, luminous flames. Very successful furnaces of this sort are rotary hearths, and these may be as much as 60 ft. O.D., over-fired by as many as 25 burners.

Reheating furnaces should heat as much steel as possible without injuring the steel or the furnace. The best combustion system would be the one that would give the highest heat transfer rate at the highest safe furnace temperature. Control panels would ordinarily include equipment for measuring, recording and controlling automatically (*a*) the fuel input, (*b*) the fuel-air ratio, and (*c*) the pressure inside the furnace.

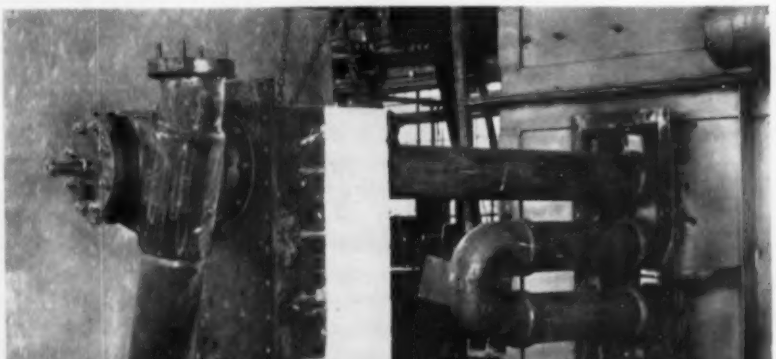
High-Speed Heating

The desire for high-speed heating is quite a factor in any furnace design. Some mention should be made of the subject here, since the steel industry has operated furnaces at rates far in excess of many new "high-speed" heating furnaces.

For example, Fig. 3 shows a cross section of a skelp heating furnace for the continuous production of butt-welded pipe. Strip steel (skelp) of various widths and thicknesses is heated to welding temperature. The furnace itself is operated as hot as can be without destroying the brickwork – as high as 3000° F. – and, as could be expected, furnace life is not long. Roof is a series of removable arches similar to the bungs or covers of the old crucible melting furnaces. As shown in the photograph, Fig. 4, the sides are an almost continuous series of burners. Heat transfer rates as high as 100,000 Btu. per sq.ft. of steel surface per hr. are obtained, a heating rate twice as fast as the nearest competitor.

Numerous other high-speed reheating operations can be found in the modern steel mill. Some of the principal ones are preheating furnaces for silicon and stainless strip, coating drying lines, direct-fired continuous tin-plate

Fig. 5 – Radiant Tube of "W" Form Partly Withdrawn From the Furnace Casing



strip annealing lines, and billet heating lines for seamless tube mills. All these high-speed lines are thoroughly satisfactory, though none approach the continuous butt-weld furnace performance as far as thermal transfer is concerned. The combustion system (instrumentation and control) is approximately the same as that used on other reheating furnaces.

Heat Treating Furnaces

Many large furnaces for heat treating steel stock – rods, bars, sheet, wire – may be found in the steel industry. Their design is usually special and adapted for a single operation on a single product. Their combustion systems parallel those for furnaces operating in the consuming industries except (*a*) the type of fuel, which may be coke oven gas or blast furnace gas, plus one other factor, (*b*) the vast tonnage which must be treated. The furnaces can be divided into two classes – direct-fired and radiant-tube furnaces.

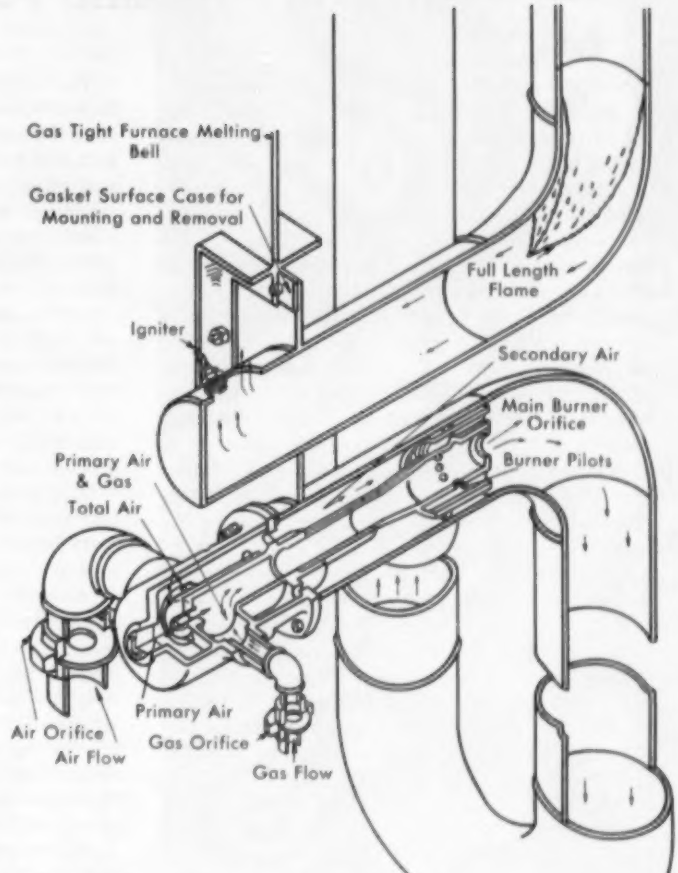


Fig. 6 – Diagrammatic Sketch of "O" Form of Radiant Tube Burner

The radiant tube was originally developed for the steel industry and is now widely used elsewhere. It burns fuel within a pipe, and the heat is transferred through the pipe wall into the furnace chamber. Burned gases from within the tube are exhausted outside the furnace. The value of the radiant tube is twofold; (*a*) it provides a means of transferring heat to a specific location in the furnace (*b*) without contaminating the furnace atmosphere with products of combustion.

This unit takes various physical forms, namely, (*a*) straight-through radiant tube (the original form); (*b*) "U" or hairpin tube; (*c*) "W" or double hairpin tube, shown partly withdrawn from the furnace in Fig. 5; and (*d*) "O" tube, Fig. 6.

These four forms have arisen as the furnace designer attempts to obtain greater combustion efficiency from each unit. In other words, the "U" tube is more efficient for a given application than the straight-through tube because a larger area of tube surface can be obtained for each burner. Each is designed to fit a specific application.

In all installations the radiant tube should have as uniform a wall temperature as possible. The more uniform the tube temperature, the better the combustion system. The burner takes many forms:

1. The high-pressure gas inspirator which induces air for combustion.

2. The nozzle-mix burner system where air and fuel under pressure are delivered with a two-pipe system.

3. The suction system, whereby a controlled suction draws both air and fuel into a nozzle-mix burner without air piping.

4. The recuperative tube, usually a modification of item No. 3 except that the combustion is drawn over the hot exhaust leg.

(Continued on page 200)

Britain's Atomic Factories

THE 100-page booklet* so entitled is the story of a "crash" program, and consequently might be compared with the so-called Smyth report† on the atomic bomb project in America. British scientists cooperated in the wartime work over here. The technical methods by which the bomb had been produced were known completely only to the Government of the United States of America. In 1946 Congress passed the McMahon Act and collaboration on many aspects of atomic energy work between the United States and Great Britain was very much restricted. The Smyth report takes the administrative and research story from 1940 to mid-1945; two British publications describe their research and production achievements since early 1946 – one entitled "Harwell: the British Atomic Energy Research Establishment", and the other "British Atomic Factories", the latter being the booklet under review.

The man chosen to direct the design, construction and operation of the factories was Sir Christopher Hinton, a distinguished engineer loaned from industry. The task was put to him in simple enough terms — merely a brief instruction to produce annually a certain quantity of plutonium, to a given specification, in water-cooled piles. The first step was to obtain natural uranium from the ore; the second was to irradiate this in piles; the third was to extract and refine the plutonium so created, and the fourth was to separate U^{235} from the natural metal. At the time there were no *engineers* in Great Britain who had any knowledge of atomic energy work. Sir Christopher's problem was to find really first-class design engineers; they could learn about atomic energy as they got on with the job. On Feb. 4, 1946 the nucleus of the design division moved into an existing ordnance factory at Risley— a total strength of 12 men and women of all ranks. Only one knew anything at all about atomic energy. The first thing was to call a meeting and ask the one informed member, who had spent some time at the Canadian atomic energy plant, to tell the rest in the simplest terms what atomic energy was. The site for the uranium refinery was a wartime chemical factory at Springfields, near Preston, and for the plutonium refinery at Windscale near Sellafield. The fourth (diffusion) plant was to be located at Capenhurst. The primary responsibility for research in matters connected with atomic energy was placed on Sir John Cockcroft and the research and development establishment at Harwell.

* From Her Majesty's Stationery Office, Kingsway, London, W.C. 2. Price 5s. net.

† See the extensive paraphrase in *Metal Progress* for December 1945, p. 1313.

The building of these factories was one of the largest engineering projects undertaken in Britain since the War; the size of the project and the speed with which it was built increased greatly the variety and magnitude of the ordinary problems such as recruiting energetic and imaginative design engineers and resourceful and efficient operating staff; getting the right quantities of materials to the right place at the right time; getting labor; providing transport and accommodation; and coordination. Affecting all of them, the designer was faced with technical and scientific difficulties that had never before been met by British engineers — arising from the fact that all the processes and many of the underlying scientific ideas were new to engineering practice and indeed to scientific thought.

It is interesting, and at first sight surprising, to find that the scientific and technical problems of most importance in the design of these factories were not concerned with nuclear physics so much as with chemistry and metallurgy. Similarly, the engineer is concerned more with the effects which intense radiation will have on the mechanical strength and stability of his materials of construction than he is with the effects upon their atomic structure. Engineers were using many materials which either were entirely new to factory operations or had not before been used on so large a scale. Materials had to be purified of some elements, boron and cadmium for example, to the highest degree. There were also the problems, metallurgical and chemical, arising from the use on a large scale of such materials as stainless steel, hydrogen peroxide, hydrofluoric acid, and many others, which were employed in greater quantities than in any previous plants.

Nevertheless, in less than five years the Production Division built a new industry worth some scores of millions of pounds; every factory came into operation within a month of the estimated date, every plant cost within a small percentage of the estimated sum.

Uranium Factory—The process used at Springfields digests finely ground ore in a warm acid mixture and filters out the insolubles. The solution contains uranyl sulphate from which crude uranium oxide is precipitated by hydrogen peroxide. The oxide is converted to uranyl nitrate with nitric acid, and trace impurities removed by "solvent extraction", the solvent being ether. The nitrate is precipitated with ammonia and can be reduced to metal (for the piles) or converted to hexafluoride (for the gaseous diffusion plant). Many unusual operations and refinements are necessary to make a complete separation of a little uranium metal

from much worthless gangue, avoid undue consumption of reagents, produce metal of spectroscopic purity, and protect plant and personnel from explosive and toxic gases and from radiation. The process was developed by Imperial Chemicals Industries as an extension of another which had produced many tons of metal during the War from oxide imported from America.

The metal reduction reaction is the most dramatic thing in the whole production process. The mixture of uranium tetrafluoride and calcium is put in a mold in a steel pot fitted with a dust collector; steel doors are closed after bells have warned workers to get out, and an operator presses the switch of a firing mechanism to initiate the reaction. Through thick green glass he watches a red glow in the heart of the mold grow rapidly whiter and bigger as it spreads through the mass of reacting material, until finally it is like a small white sun spitting stars into the dark of the enclosing chamber. Then the spitting dies down, the reaction is over, and a slowly cooling mass of uranium is left. The cold billet is scarfed, analyzed, remelted in an electric furnace and vacuum cast into ingots ready for rolling into round bars.

At first, all wastes were stored. A plant for recovery of valuable materials from them is now constructed. Another point: These plants are among the cleanest in the kingdom, to protect both the health of the workers and the purity of the product. Wherever there is exposed process material, buildings as well as plant are cleaned every shift.

Springfields is a large factory, yet it was designed, built, and brought into production in the planned time of only 30 months.

Plutonium Factory at Windscale — In 1945 the only plutonium-producing piles known to be operating anywhere in the world were the air-cooled experimental pile at Oak Ridge and the water-cooled production units at Hanford, both in America, and the British workers had not participated in their design and had been given access to very little information about them. In short they were starting from scratch in this field.

With so little experience to go on it was early decided to concentrate on the simplest type, the slow-fission natural-uranium graphite-moderated unit. The main debate was about the cooling method. Water cooling is efficient and well established at Hanford, but for the United Kingdom has two major disadvantages. It requires very large quantities of water extremely free from chlorides and the necessity of locating the factory 50 miles away from any town. (The water coolant absorbs and takes away some neutrons while air coolant does not; hence, in the highly unlikely event of simultaneous failure of the water system and the other controls the neutron population would multiply so fast the temperature would shoot up much more rapidly than if the pile were air cooled.)

Windscale Plutonium - Producing Factory at Sellafield, Cumberland

A long search revealed only one site that really met the requirements.

In the meantime Risley engineers studying the gas-cooled pile showed that it would be possible to fit fins to the cartridges, and so increase the efficiency of cooling so a production pile could be cooled efficiently by blowing air through it at atmospheric pressure. Moreover, it would be inherently safe. One of the advantages of the straight-through air-cooling system used in the Windscale piles is that it makes the loading of fresh uranium cartridges and unloading of spent or irradiated ores a simple matter, at least as compared with a pile cooled by gas under pressure or by water. The new cartridge is simply (*Continued on page* 186)

Vacuum Melting Furnaces – An Interim Report

*By FRANK CHESNUT**

A historical sketch of vacuum melting is followed by a description of modern induction furnaces which can make 1000-lb. ingots, and others for arc melting in vacuo such difficult metals as molybdenum and titanium. (C 25, D 8)

In the depth of the depression, when I had more time on my hands than money in them, I did some outside patent work, and I well remember one job which to this day has amazed me. I was asked by a major producer of oil well equipment to send him a copy of each U. S. patent relating to hydraulic clutch or power transfer mechanisms. His interest was in a braking mechanism for heavy well-drilling tools. In an art which was publicly unknown at the time, I found 3265 patents! You will recall that the first fluid drive on a commercial automobile was still nearly eight years away.

Now why this build-up? When organizing the program for this meeting of the Industrial Heating Equipment Assoc. it was the almost unanimous opinion that one paper be on "Vacuum Melted Metals". Interest in this subject is great. While there have been many papers about it recently, the average ASMer is still probably in the dark as to what he should or could do about it. Ajax Electrothermic Corp. was assigned the task "to make an appraisal of existing types of vacuum melting furnace installations and techniques, to show where and in what quantities vacuum metals are being used and their availability and competitive position in today's industry". I am sure I have found "3265" references and just as sure that large-scale commercial use is not for today but perhaps for a not-too-distant tomorrow.

Early Studies

Vacuum melting furnaces and induction heating have grown side by side. One of the very first applications of induction heating was the heating of vacuum tube parts for an outgassing operation. Among the earliest patent applications filed by Northrup were those for vacuum melting furnaces of one type or another.

The most common variety of vacuum melting furnace consisted of an evacuated tube with the melt inside and the inductor coil outside. Literally hundreds of these furnaces were sold to research laboratories in the United States. Charges rarely exceeded 5 lb.; the melts were usually frozen in the crucibles before being removed from the vacuum. Pressures were more of the order of millimeters or fractions, rather than in the micron range.

In the early 1920's most melts were made by research scientists for measuring melting and freezing points and for making samples of pure refractory metals like tungsten, platinum or molybdenum. At no time was there a dead period in the study of vacuum melted metals.

What were the reasons for this inquiry into vacuum melting? Summed up, a cleaner metal or alloy can be made than the usual product of conventional melting, and the engineer and metallurgist were interested in what improved properties could be obtained from these clean metals. But "clean" is an entirely relative term; what might be considered clean under one set of conditions, or for a given purpose, might not be considered clean for a different set of con-

*Electrical Engineer, Ajax Electrothermic Corp., Trenton, N.J.

Editor's Note – Mr. Chesnut's paper discussed both melting furnaces and metal therefrom. Only the first portion is printed in this issue; the second portion will be integrated with a report in December's *Metal Progress* of the A.S.M. conference on vacuum melted metals held at the National Metal Congress and Exposition.

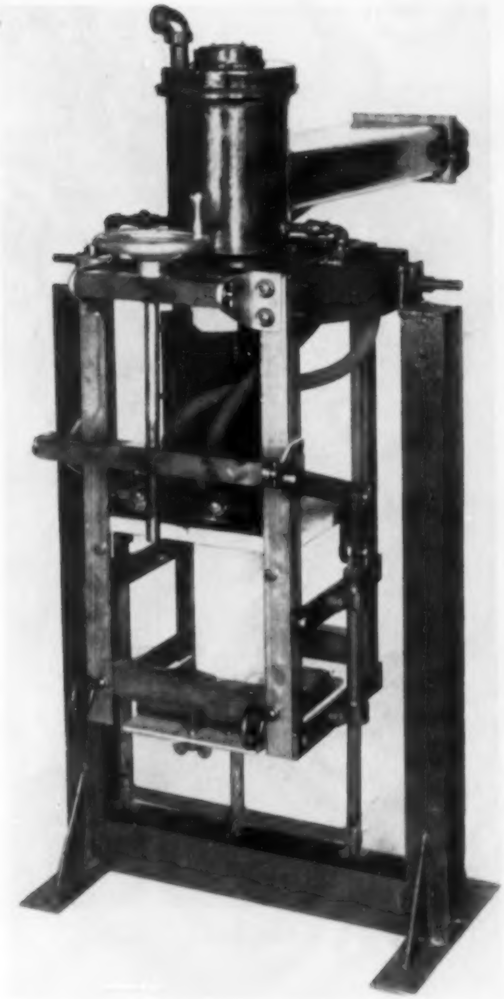


Fig. 1 – (left) Modified Reeve Furnace With Metal Casing. Mold is in arm extending to rear. Metal is poured by tilting assembly 90°

ditions. Each succeeding generation of artificers and metallurgists has made what they thought to be "clean" metal, but only in the past decade has the vacuum furnace given the metal maker some control over the intractable impurities and traces of gases in his metal.

A clean metal, in today's parlance, is one which is substantially free from all unwanted compounds and has substantially the exact analysis desired. In some minds it must also have a desired structure or crystal pattern. Vacuum melting, in one way or another, is providing a means for making clean metal.

At the very least, air can be excluded from around the metal while it is being melted, the readily oxidizable components are protected from further oxidation, undesirable oxides already present may be reduced by carbon or hydrogen, or the sulphides eliminated by suitable metallic oxides. Any nitrides and hydrides which are unstable at low pressures break up and can be pumped off. The raw material is first class, already "refined", so no slags are required and the danger of trapped inclusions is a minimum if the crucible is sufficiently resistant to scour. Impurities with low boiling point such as magnesium, lead, zinc and the like can also be vaporized and drawn off. Since melting losses are low and predictable, the composition of the melt can be maintained within extremely close limits.

Theoretically, the whole operation, from the time power is applied to the furnace to the cooling of the ingot or casting in the mold, can be carefully controlled as to temperature, degree of vacuum or preferred atmosphere, and order of adding constituents. Finally, what scrap results from the operation can usually be fully reclaimed for future remelting.

This is an exciting list of possibilities. I will now trace briefly the developments in furnaces and auxiliaries which have translated these items from hopes into practicable realities.

Casting Methods

As remarked above, the first vacuum melts were solidified in their crucibles. A button of this sort is not a very good forging billet so next came the casting of metals in vacuum. First models used molds inverted and placed over the crucible. When melting was completed, the assembly was rotated 180° and the melt dumped into the mold. Later models had special fused silica tubes with side arms containing the mold; in some of these assemblies the charge could be watched during the melt and the whole furnace tilted 90° to pour. These furnaces, devised by Reeve of Western Electric Corp. and later perfected by making the entire upper part of the assembly and mold arm of metal (Fig. 1), were used, and still are, in production melting charges of steel and other alloys weighing up to 10 lb. In some of these units additions could be made to the melt under vacuum; pressures were fully comparable to the best achieved today.

Motor-Generators for Power

The power source for the early vacuum furnaces was the Northrup spark-gap converter, but in the early 1930's, motor-generator sources of supply became available and vacuum furnaces acquired a new look. With the lower voltages now obtainable the inductor coil can be placed

inside a steel shell and the whole assembly evacuated without too great danger of arcing.

The first furnaces of this sort were built in capacities ranging from 50 to 300 lb. of steel. Crucible and inductor coil were placed in one cylinder and the mold was placed in an arm extending outward from the main cylinder. Access covers and viewing ports were placed at strategic places.

An objection soon developed – the charge not only had to be poured over the lip of the crucible but also down the side of the mold. This brought the next improvement, namely, the pivoted mold, shown in Fig. 2.

It is interesting to note that during the 1930's the voltage used on these furnaces was usually 600 – a very significant fact which will be referred to later.

Wartime Influences – There is no doubt that World War II and the atomic energy program did more to expedite progress in vacum melting than any other single thing. It created a demand for *production* units and there were no strings on the pocketbook. Every idea that looked feasible was adopted. Silica sleeve vacuum chambers with converter-operated furnaces had been widely used in research. They worked. Converters could be obtained quickly and they were ordered. Generator equipments were also ordered. Some generator-operator furnaces were of the external inductor, fused silica tube type; others had steel tanks with inside inductors. Both types were enlarged step by step as production demands grew and as the efficiency of vacuum equipment kept pace with furnace development.

As vacuum equipment was improved, operating pressures were reduced. As pressures were reduced, furnace voltages also were reduced. Each drop in voltage, however, worked against size, because the current requirements for large furnaces were becoming a problem. Leads had to be shortened, buses redesigned to eliminate excessive voltage drops, switching had to be reduced to a minimum, and even the coil design had to be changed. Even after the war, when still larger furnaces for melting steel alloys were in demand, producers glibly talked of 1000-lb., 2000-lb., and 10,000-lb. furnaces without realizing that amperages of 10,000 already were in the works and each increase in size of furnace or decrease in voltage meant more trouble.

Fig. 2 – Vacuum Furnace With Swinging Mold

Large Furnaces for Clean Metal

Fortunately there were some bold but clear thinkers in this field. Foremost, I like to credit James D. Nisbet, then of the General Electric Co. but now director of research for Universal-Cyclops Steel Corp., with some of the most forward thinking on large furnace design. Almost from the beginning he was willing to punch more holes in his vacuum shells for more control gadgets. Almost at the start he visualized large "walk-in" furnaces; and he, almost alone, was willing to risk higher voltages which allowed larger furnaces to be built. At Universal-Cyclops, his was the first 1000-lb. unit to be put into commercial production (see Fig. 3). The vacuum equipment for this installation was supplied by

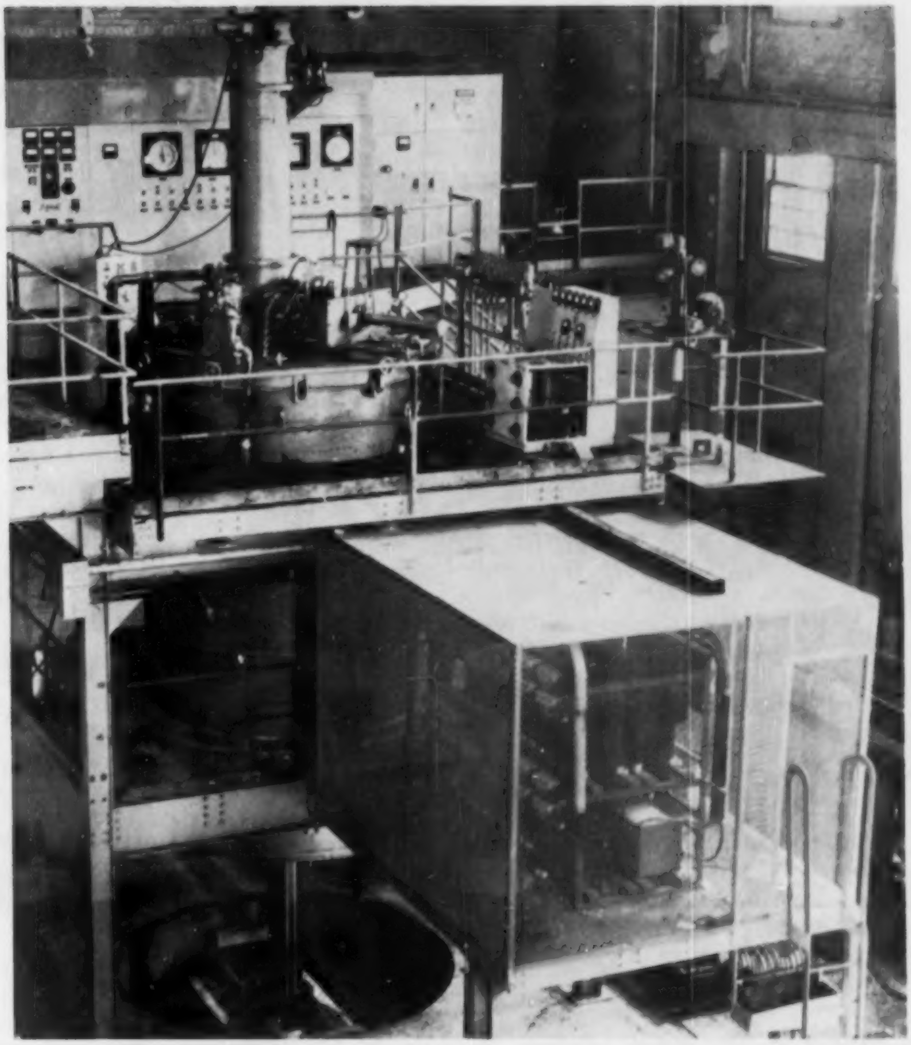


Fig. 3 — Vacuum-Induction Furnace and Auxiliaries Installed at Bridgeville (Pa.) Plant of Universal-Cyclops Steel Corp. It can produce six 1000-lb. ingots before the vacuum need be broken

Consolidated Vacuum Corp., the large vacuum shell by F. J. Stokes Machine Co., and the induction furnace equipment by Ajax Electrothermic Corp. The furnace receives its charge through a vacuum lock and the furnace itself is designed to cast six 1000-lb. ingots before breaking the vacuum. Special arc heaters used as hot tops insure flat-topped ingots with a maximum percentage of usable metal.*

The Carboloy Division, through its parent the General Electric Co., has been a pioneer in the development of vacuum metallurgy. Its background in vacuum melting dates from 1946 and in induction melting for a considerable period before that. In its Detroit plant it operates a 350-kw., 1000-lb. equipment diagrammed in Fig. 4. The services to which it is put are three-fold: (*a*) to furnish vacuum melted alloys of conventional analyses to the consuming industries, (*b*) to melt special alloys to a customer's specification and (*c*) to develop new analyses for specific requirements.

As was mentioned earlier, cleanliness of an alloy is a relative term and hence the degree of

*A brief description of this furnace was given in "Critical Points", *Metal Progress*, Oct. 1954, p. 113.

refinement needed to make "clean" metal varies over wide limits and a wide variety of furnaces or processes is available. These may conceivably vary from a vacuum degassing device (which is operated only after a metal has been melted in conventional equipment, to suck off certain of the dissolved gases before the metal is poured into a mold) to a straight induction melting furnace operated under slag blanket, inert atmosphere, partial vacuum, the highest possible vacuum or various cycles of vacuum and atmosphere.

Variations – Under this heading might come a number of combinations, perhaps the foremost being the remelting under an inert atmosphere of metal previously melted and refined under vacuum. Once having been cleaned of its gases, metal carefully remelted under such an inert atmosphere can be made to retain many of the characteristics of a true vacuum melted alloy, especially so since the raw material may be in such a form that it can be easily melted with little time to react with the crucible.

Vacuum degassing is a method wherein the metal is melted in a conventional way and the crucible or ladle holding the molten metal is subjected to a vacuum treatment. The melt must be superheated enough for heat loss during the degassing cycle, and if it has essential constituents with a low boiling point or high vapor pressure an excess must be present, or more must be added, to balance the losses in the process. Pressures of 10 to 100 microns have been employed for 5 to 15 min. depending upon the size and composition of the charge. In America this type of degassing has been done on relatively small charges of bronze and aluminum.

In Europe, charges of steel up to 150 tons are said to have been favorably degassed for such purposes as inductor shafts, turbine rotors, silicon steels for electrical purposes, and alloy steels. After degassing the metal may be removed from the vacuum chamber for conventional casting, or it may be teemed from the bottom of a transfer ladle directly into a large mold or ingot in the vacuum chamber. This process eliminates much of the nitrogen and hydrogen from the melt and is said to be well worth its expense for the class of work it serves but it does not permit as complete a clean-up as melting, treating and pouring, all under vacuum.

Vacuum Arc Furnace

Against the induction furnace is the fact that a crucible or refractory wall must hold the metal and some gas may be given off at the hot junction where metal and refractory meet. This disadvantage is avoided to a degree by the vacuum arc furnace, which has proven useful in the commercial production melting of molybdenum and titanium. Several designs of vacuum arc furnaces have been succesfully operated; substantially all are of the cold hearth type, but some are adapted for casting and others for producing a semicontinuous casting or ingot. The greatest difference lies in the use of a consumable type or water-cooled type of electrode.

In the consumable-electrode furnace for producing sizable ingots a vacuum shell is provided with a water-cooled copper base plate or mold which may or may not be lined by a protective sheet or layer of metal similar to that which is to be cast. An electrode, composed of powder, scrap ingots or turnings of the metal to be cast,

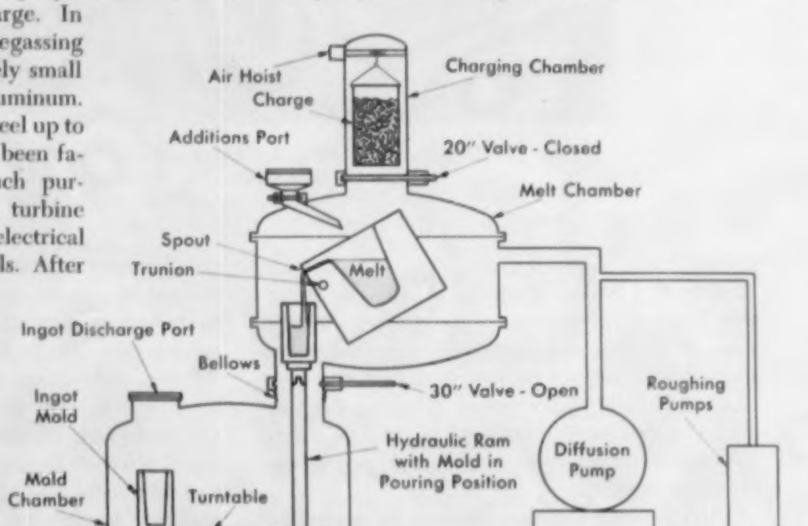


Fig. 4 – Diagram Showing Components of the Vacuum Furnace at Carboloy Div., General Electric Co., for Charging, Melting and Casting 1000-Lb. Melts, One Following Another

enters this mold along its axis. This electrode is hard pressed and sintered so it will hold its shape during the casting process. A piece of scrap or an ingot end may be placed in the mold as a starter. In operation the shell is evacuated or filled with an inert gas, the mold and electrode are energized with alternating or direct current and the consumable electrode is lowered to strike an arc. The arc melts a portion of the starting electrode or scrap and establishes a gradient between the pool of molten metal and the solid metal next to the water-cooled mold. With this start, melting progresses until the electrode is substantially all melted and solidified into the mold below. One electrode may furnish all the metal desired in a small ingot. If not, arrangements are made for bringing electrodes into action, one after another, or an endless electrode may be formed from powder or scrap by a mechanism within the vacuum tank.

The main advantage of arc melting is that there is no refractory crucible to react with the metal. It also has an advantage of simplicity; processes once worked out can be made substantially routine or automatic, to build up fairly large ingots which can be worked with existing mill equipment.

Highly reactive metals probably can be melted best in such cold-hearth arc furnaces. For titanium such furnaces might be considered indispensable in the present state of the metallurgical art. I venture to predict, however, that the range of alloys which can be handled will be much narrower than produced in the more versatile vacuum induction furnaces, and that maintaining close analyses of the more complex alloys will be quite difficult.

Molybdenum – Norman L. Deuble has described in full detail in *Metal Progress* for April 1955 the furnaces used by Climax Molybdenum Co. for making a 9-in. round, 4-ft. long, 1000-lb. ingot of molybdenum every 90 min. This figures a melting rate of 12 lb. per min. Power is 360 kw. at 60 volts, alternating current; the vacuum is 2 microns.

Titanium – Titanium is made by similar methods. For example, Titanium Metals Corp. at Henderson, Nev., presses electrodes from raw sponge, scrap, and alloying elements. Vacuum is 0.2 to 0.3 micron, and no gas cover is used. Double melting is practiced both here and by Mallory-Sharon Titanium Corp. The first-run ingot needs to be scalped deeply if it is to be rolled direct; if remelted the surface is smooth enough for successful hot working. Scrap (turnings) is avoided, and more damaging hydrogen has been sucked out.

Casting Titanium Shapes – National Research Corp. has operated a cold electrode furnace for casting titanium shapes weighing up to 50 lb. in vacuum or inert atmospheres. The furnace is not unlike those for casting ingots except that the lower electrode is a disk-shaped graphite crucible within a stainless steel shell, and the upper electrodes are nonconsumable water-cooled tungsten type. Three electrodes, each taking 900 to 1000 amp. from individual d-c. welding generators at 25 to 30 volts and arcing to the titanium held in the graphite crucible, provide the heating energy. A water-cooled copper cover provided with molybdenum radiation shields prevents excessive radiation from the arcs and from the molten bath.

The chamber can be tilted and a mold receives the melt. In operation, the shell is evacuated to 0.2 micron or less and then is filled with argon to about 200 mm. Hg pressure. Melting then begins. A skull of titanium, previously set in the graphite crucible, remains solidified and prevents the pool of molten titanium from absorbing carbon. Special care must also be taken to prevent contamination of the metal by the mold before solidification.

A molten bath of some 12 in. diameter and 2 to 3 in. deep can be maintained. Power consumption is said to be approximately 1 kw-hr. per lb. of melted metal.

Conclusion

From the above, it should be evident that the metallurgist now has workable equipment for producing conventional alloys of unusual cleanliness and freedom from dissolved gases. Ingots of commercial size can also be made of highly reactive metals. The limitations in the latter come more from the nature of the crucible or mold than from the atmosphere.

In the sequel, to be presented in *Metal Progress* next month, I believe that a fairly clear case can be presented to show the superiority in many respects of vacuum melted metal. However, it is not yet clear that industry at large is willing to evaluate them so highly that it will specify vacuum melted metals rather than metals carefully made in the ordinary induction furnace operated in air. Metals melted under ordinary or inert atmosphere, with or without the benefit of previous vacuum melting, still are widely competitive with the run-of-mine vacuum melted metals for all but a few applications.

Correspondence . . .

The Russian Scientists at Geneva

GENEVA, SWITZERLAND

Perhaps readers of *Metal Progress* will be interested in some observations about the Geneva conference on atomic energy other than those in the general press made by newsmen. This meeting was really no more newsworthy than any of the large technical and engineering conferences or conventions occurring constantly in the United States. This fact, in all likelihood, is the *real* news!

The principal Russian metallurgists present were: G. V. Kurdiumov, G. S. Zhdanov, A. M. Samarin and G. A. Meierson. The last two mentioned may be known to numerous Americans for they were in your country in earlier, freer, days. In my opinion, Kurdiumov's paper on diffusion and atomic interaction in metallic systems (No. 702 in the program) and Samarin's on the use of radioactive tracers in the iron and steel industry (No. 707) should receive much attention by physical metallurgists and by production metallurgists.

One of the Russian papers described an advanced laboratory for "hot" mechanical testing and metallography. S. T. Konobeevsky (unfortunately not present in person) gave in paper No. 681 some excellent micros – both optical and electron – of *highly* radioactive metals and alloys, including a uranium-molybdenum alloy which reverted from a stable two-phase structure to unstable homogeneous gamma after undergoing fission!

One gets the impression that their design and construction of reactors is not too ingenious. For example, they appear to use stainless steel where you have used metals which capture a far smaller number of free neutrons.

But the most important news is that Russian metallurgists and scientists are people. How easy it is for scientists of different countries to talk together with good will! Good for everyone will come of it.

So far I have said nothing but of the Soviets. At the conference the United States was strongly represented, making a really magnificent show. England also came forward with some very good papers. The other countries made relatively few contributions.

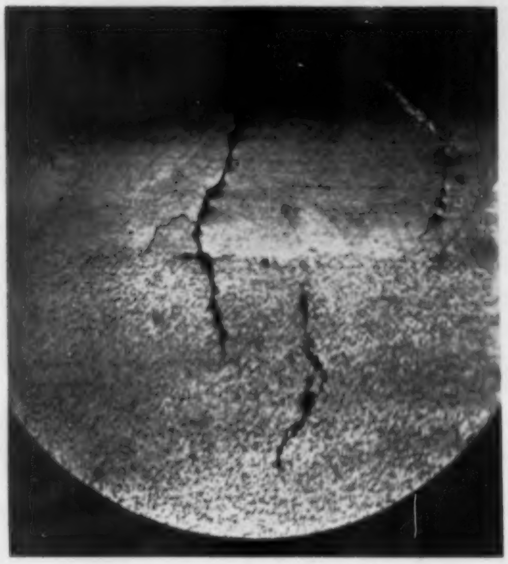
In the exhibit, America was overwhelming. The "swimming pool" reactor in operation, with its unearthly purple glow, was of course the prime attraction, but the models of the other reactors and the display of fuel elements were exceedingly attractive. The industrial exhibit of the United Kingdom was also very good. In fact, the whole industrial exhibition was so impressive it leads to the conclusion that a businessman could buy almost everything he needs instead of having to make it. Nucleonics is already an established industry.

RAY DECAY

Unusual Stress-Corrosion Crack

SEATTLE, WASH.

An unusually severe instance of stress-corrosion recently came to our attention. A tank truck, normally used for liquid fuel, made one trip when filled with aqueous ammonium nitrate, and numerous leaks started at the welds. Chemical analysis of the steel showed nothing suspicious; it was specified as 5110 and the content in manganese and chromium was on the low side. However, large ferrite grains (A.S.T.M. No. 1) were found on the surface extending ¼ in. on either side of the welds. This coarse-grained surface layer was about 0.02 in. thick; the sheet was 0.14 in. thick and its grain size No. 8. The micrograph shows this surface layer of coarse-grained ferrite in which stress-cor-



Large Grains on Surface Alongside Welds in Steel Tank. Stress-corrosion cracks extended inward into fine-grained core. 50 ×, light nital etch

rosion cracks have formed, and a stress-rupture in the underlying fine-grained material. At other places the surface cracks clearly followed the grain boundaries.

Other tests showed that hydrogen embrittlement had no part in the failure. Rockwell hardness of the normal base sheet was 77, of the corroded area it was B-72, and hardness of the weld metal was B-93.

We believe that failure was rapid and severe because of the large grain size. At one place one grain, when separated by corrosion, produced a notch large enough to become the focal point for stress concentration.

T. H. Williams
Northwest Laboratories

Thermal Shock of Cast Turbine Blades

London, England

In "A Turbine-Blade Alloy Castable and Low in Cobalt and Columbium" published in the January issue of *Metal Progress*, p. 141, the authors characterize as erroneous the belief that cast blades are generally less resistant to thermal shock than forged blades. It was furthermore stated that cast blades can possess as good strength properties as the forged alloys.

It would appear that the Swiss authors have based their conclusions on test blades which were simply machined and finished out of large forged pieces, and that neither "close to form" nor "precision forging methods" in closed dies were employed. In both the United States and Great Britain a large number of blades are produced in closed dies, either close to form or precision forged, and we feel that the conclusions of the Swiss authors must be rejected as unauthentic and of no practical value.

P. Granby
Managing Director
Paul Granby & Co., Ltd.

Winterthur, Switzerland

It is correct that a large number of blades are produced in closed dies, either close to form or precision forged; also that we have compared cast test blades and blades that were simply machined and finished out of large forged pieces. In Switzerland, as well as other countries, blades are also made by precision forging but more frequently out of forged bars. From our comparison it has been determined that cast blades stand up to thermal shock just as well as machined and finished blades, although it should be noted that no comparison has been made with precision forged blades.

W. Siegfried and F. Eisermann
Sulzer Brothers, Ltd.

Specifications for Hard Facing Alloys

Mahwah, N. J.

Culminating between four and five years of work, the committee on Surfacing Filler Metal jointly sponsored by the American Welding Society and the American Society for Testing Materials, has agreed upon a tentative specification for hard facing alloys. Such a specification has been difficult to write because the alloys have been largely proprietary and their useful properties are hard to measure. The present document still suffers from the second limitation, but it should aid both the producer and the user of hard facing alloys.

In all, 43 specific grades are grouped in six important groups of surfacing alloys, namely, high speed steels, austenitic manganese steels, austenitic high-chromium irons, chromium-cobalt-tungsten (stellite type) alloys, nickel-

chromium-boron alloys, and copper-base alloys. Chemical composition ranges are fixed, as well as sizes of welding rods and electrodes, details of packaging and physical quality details. Informative appendices are added.

There are other groups of facing alloys not yet included, and the committee expects to add continuously to the specification as rapidly as composition ranges can be sharply defined and matching technical data can be assembled for the correlated appendix. Specific information from any manufacturer or user would be more than welcomed if they follow the lines of the criteria used to establish the groups for this initial draft: *(a)* approximate industrial standardization, *(b)* materials covered only by expired patents, if they have been patented, *(c)* availability from more than one manufacturer, and *(d)* availability of data for the appendix.

Comments from individuals who received a preliminary draft have indicated that the appendix is the most useful part of the specification. For each alloy some information is provided about applications, hardness as welded, hot hardness, impact behavior, oxidation and corrosion resistance, abrasion resistance, metal-to-metal wear, properties under compression, machinability, identification criteria, metallography, heat treatment, and welding characteristics.

The amount and quality of available information differ, alloy to alloy. While the committee was not satisfied with some of the items, the present document was released subject to improvement in later versions. The greatest lack is any generally accepted criteria of service performance and standards of weld quality.

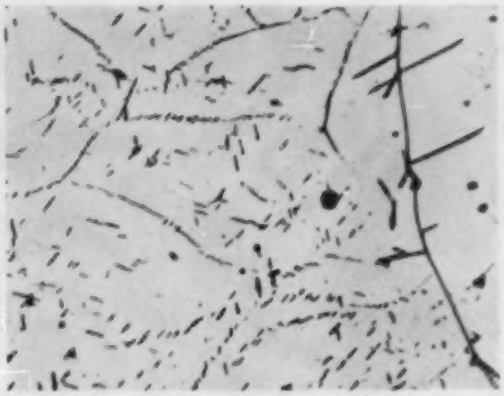
HOWARD S. AVERY
Research Metallurgist, American Brake Shoe Co.

Air as a Nitriding Gas

CONSHOHOCKEN, PA.

I would like to report some observations on a little suspected difficulty occasionally met in the manufacture of steels for deep drawing, and invite correspondence from others who may have observed similar anomalies.

Nitrides were found in the surface microstructure of low-carbon openhearth steel slabs rejected for badly cracked edges and suspected of having been overheated in the soaking pits. Several sound slabs of similar composition were examined for comparison, but nitrides did not appear in their microstructure.



Nitrides Picked up by Low-Carbon Openhearth Steel During 2.5 Hr. Heating in Air at 2475° F. 1000 ×. 2% nital etch

At first it seemed that the nitrogen in the defective slabs may have been picked up from the fuel gases in the soaking pit rather than from the atmospheric air. To check this assumption, small mild steel samples were heated to high temperatures in an open electric furnace. Specimens approximately 0.220 in. thick and of known weight and volume were annealed at temperatures above those normally running in soaking pits. These specimens were furnace cooled to coalesce any iron nitride; they were then pickled, measured and weighed. One pair of specimens was heated for 2.5 hr. at 2475° F; the other pair for 3 hr. at 2515° F. While in the furnace, both pairs rested on a block cut from a sound, low-carbon steel slab.

Each specimen and their supporting blocks contained nitrides in their microstructures. In the block they were confined to the surface zone. The micrograph shows one of the specimens annealed at 2475° F. The nitrides are precipitated in a general Widmanstätten pattern as well as along what appear to be sub-grain boundaries.

Nitrogen was determined by the Kjeldahl method by William F. Schniepp, chief chemist of the Alan Wood Steel Co., in several samples in both the original and heat treated conditions. The analytical results indicate that the nitrogen content of the specimens increased several fold during annealing while they simultaneously lost about half their volume or weight. It therefore appears that mild steel will absorb nitrogen directly from the air when heated in the high-temperature austenite region.

REED KNOX, JR.
Research Metallurgist, Alan Wood Steel Co.

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Personal Mention

A. E. Nehrenberg

Peter Lillys

Kenneth E. Rose

The Henry Marion Howe Medal of the American Society for Metals for 1955 has been awarded to A. E. NEHRENBERG and PETER LILLYS of Crucible Steel Co. of America. Their paper, "High-Temperature Transformations in Ferritic Stainless Steels Containing 17 to 25% Chromium", was judged to be of highest merit among the published metallurgical contributions in the *Transactions*, Vol. 46, 1954.

Graduating from South Dakota School of Mines and Technology in 1937 with a B.S. degree in chemical engineering, Mr. Nehrenberg took postgraduate work in physical metallurgy at Armour Institute of Technology and Columbia University. His professional career began in 1937 when he went to Carnegie-Illinois Steel Corp. as a metallurgical observer in the process control division at the South Chicago Works. He later became assistant metallurgist in the production laboratory, and in 1942 joined the U. S. Naval Ordnance Plant at Forest Park, Ill., as head of the physical metallurgy section. He was promoted to metallurgist in charge in 1943, serving in this capacity until 1945. Since 1945 he has been associated with Crucible Steel Co. of America, where he is at present supervisor of the research laboratory in Pittsburgh.

PETER LILLYS, co-author, with Mr. Nehrenberg of the Howe Medal Award paper, is a native of Brooklyn, N. Y., and a graduate of Rensselaer Polytechnic Institute with a bachelor's degree in metallurgy. Following graduation he joined the staff of Crucible Steel Co. of America, where he is now a research metallurgist in the research laboratory. Mr. Lillys has contributed to a number of technical papers and articles, and has also submitted several photomicrographs to the Metallographic Exhibits, several of which have been judged best in class.

George L. McCauslan has been promoted from superintendent of detinning at the East Chicago, Ind., plant of Metal & Thermit Corp. to superintendent of detinning and chemicals and transferred to the Carteret, N. J., plant.

J. G. Cametti has been in England since August, where he will remain for one year as resident representative of the Westinghouse Electric Corp., at Rolls-Royce, Ltd.

P. E. Page has been retired by the U. S. Navy as Commander after 38 years of service. The last position held by Commander Page in the Navy was Inspector of Naval Material, Buffalo, N. Y., district.

KENNETH E. ROSE, professor of metallurgical engineering and chairman of the department of mining and metallurgical engineering at the University of Kansas, was the recipient of the Teaching Award for 1955, which was presented at the annual banquet of the Society last month. The $2000 cash award is given annually to a young (under 40) college or university teacher who, in the judgment of the Awards Committee, turns in the best all-around performance in the metallurgy curriculum. Professor Rose graduated as a metallurgical engineer from Colorado School of Mines in 1939, and obtained his M.S. degree in 1943 from Cornell University, where he also was an instructor in mechanics and metallurgy for two years. His wide experience in metallurgical education includes the organization and teaching of extension courses at the University of Kansas, as well as conducting the 1955 summer courses in metals technology for high school teachers. A past chairman of the Kansas City Chapter, Professor Rose is also a member of the American Institute of Mining and Metallurgical Engineers, American Foundrymen's Society, American Association of University Professors, American Society for Engineering Education, and is listed in "Who's Who in Engineering".

George C. Towe has resigned as research engineer at the scientific laboratory of Ford Motor Co., Detroit, to become an assistant professor in the department of physics at Montana State College.

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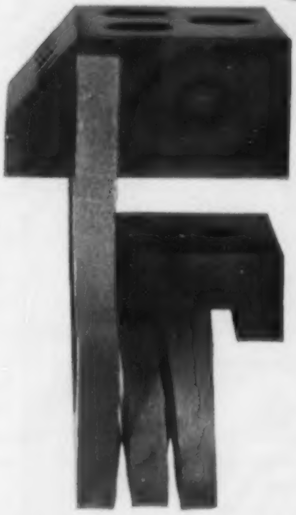

Actuating mechanism, showing overload coil brazed to two Revere Extruded Shapes.

Overload device, OD-2, made by I-T-E Circuit Breaker Company, 19th & Hamilton Sts., Philadelphia, Pa., using Revere Copper Extruded Shapes.

Here is a photograph of the I-T-E Dual Selective Overcurrent Trip, an air circuit breaker part. It contains two Revere Extruded Shapes, in copper. In the detail view, the beveled shape at the top is furnished in Free-Cutting Copper, to speed up the drilling and tapping of the holes. The piece below it was originally milled from rectangular copper bar, 1 x 2 inches. The bar weighed 7¾ lbs per foot, and 1.8 lb of scrap per foot was generated in machining it to the angular form shown. The company then switched to a Revere Extruded Shape, weighing a little less than 6 lbs per foot. Though the shape inevitably costs more per pound than the bar, the reduction in weight was sufficient to save almost 44¢ per foot over the bar, and of course additional savings were realized in reduced machining time and in scrap handling. Production also was speeded up. This is an outstanding example of the economies offered by shapes.

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Personals . . .

Gregory Kobrin, who graduated last June from the University of Connecticut with a bachelor's degree in chemistry, is employed as a chemist-metallurgist in the technical section, engineering group, E. I. du Pont de Nemours & Co., Belle, W. Va.

Richard D. Seibel has joined the staff of the Denver Research Institute, Denver, Colo., as a research metallurgist. Mr. Seibel was recently discharged from the U. S. Army after serving two years at the Watertown Arsenal Laboratory.

John S. Rinehart has resigned as research physicist at the U. S. Naval Ordnance Test Station, China Lake, Calif., to become assistant director of the Astrophysical Observatory of the Smithsonian Institute, which was recently moved to the Harvard University Observatory campus. Dr. Rinehart will conduct metallurgical and fracture studies of meteorites and meteoritic debris.

William E. Hopkins has been transferred from the operating department of the brake shoe and castings division of American Brake Shoe Co., Melrose Park, Ill., to the engineering department of the same division at Mahwah, N. J.

Philip R. White is now a member of the technical staff of the research metallurgy department of Bell Telephone Laboratories, Inc., Murray Hill, N. J., after six years with the research laboratories division of General Motors Corp., Detroit.

James B. Russell recently accepted a position as metallurgical engineer, development group, with the Nichols Wire and Aluminum Co., Davenport, Iowa. During the past seven years he was employed as research metallurgist, Kaiser Aluminum & Chemical Corp., Spokane, Wash., and prior to that served over four years in the U. S. Navy as research metallurgist, Naval Research Laboratory, Washington, D. C.

Robert E. Boni, formerly research metallurgical engineer with Timken Roller Bearing Co., Canton, Ohio, is now a member of the U. S. Army in metals research at Watertown Arsenal Laboratory, Mass.

Arthur H. Allen, for over 20 years associate editor of *Steel* in Cleveland and Detroit, and in recent years handling special editorial assignments for *Metal Progress*, has opened new offices in Cleveland and is continuing in the field of technical-business writing for publications and industrial organizations.

W. Fear, after graduating from Purdue University in June with a bachelor's degree in metallurgical engineering, accepted a position as trainee in the Trentwood, Wash., works of the Kaiser Aluminum & Chemical Corp.

Harris M. Sullivan has been appointed manager of the electronics laboratory of General Electric Co., Syracuse, N. Y.

Ben Litt, formerly metallurgical failure analyst with Wright-Aero Div., Curtiss Wright Corp., Wood-Ridge, N. J., is a mechanical engineer-metallurgist with Nuclear Development Associates, Inc., White Plains, N. Y.

Stan S. Thomas is assistant professor in mechanical engineering at the University of Notre Dame, after having been on the staff in the department of machine design at Cornell University for three years.

Personals . . .

Richard P. Dunphy, formerly metallurgical consultant, engineering services division, Naval Research Laboratory, Washington, D. C., is now assistant to chief metallurgist, engineering products division, Radio Corp. of America, Camden, N. J.

Edwin R. Emery, formerly with Vulcan Crucible Steel Co., West Aliquippa, Pa., is now an assistant engineer for Westinghouse Electric Corp., Blairsville Metals Plant, Blairsville, Pa.

Walter M. Saunders, Jr., for 27 years associated with the company founded by his father 55 years ago, Walter M. Saunders, Inc., has sold his interest in the firm to become treasurer of the Northampton Cutlery Co., Northampton, Mass.

Dean K. Hanink, formerly supervisor in the metallurgy department of the research division, has been transferred by General Motors Corp., and promoted to chief metallurgist, turbo-jet engineering, Allison Div., Indianapolis, Ind.

Theodore G. Megas has been transferred by Bethlehem Steel Co., from contact metallurgist in the Bethlehem plant to sales engineer in the Buffalo, N. Y., sales office.

Paul Andre Albert, who recently received his D. Sc. degree in metallurgy from New York University, is now employed in the magnetic materials development section of Westinghouse Electric Corp., East Pittsburgh, Pa. Dr. Albert was formerly a research assistant in the metallurgy section of New York University research division.

E. D. Veilleuk has accepted a position as junior engineer in the standards department of the Heald Machine Co., Worcester, Mass.

Stanley Zirinsky, formerly senior engineer in the atomic energy division of Sylvania Electric Products, Inc., Bayside, N. Y., is now a materials engineer in the special defense products division of General Electric Co., Schenectady, N. Y.

Durmus Attila, formerly metallographer for Budd Co., Philadelphia, is foundry process engineer, International Harvester, Chicago.

Personals . . .

Walter E. Gruver, Jr. is now a metallurgist in the research and development division of Meehanite Metal Corp., Yonkers, N. Y.

Cecil J. Bier is now working in the metals engineering section of the Knolls Atomic Power Laboratory of General Electric Co., Schenectady, N. Y. His previous position was as section head of the atomic energy division of Sylvania Electric Products, Inc., Hicksville, L. I.

Fred J. Poss has resigned from E. I. du Pont de Nemours, Inc., Savannah River (Ga.) plant, to accept a position in the atomic power department of Westinghouse Electric Corp., Pittsburgh.

Philip Hansen has been transferred by Bridgeport Brass Co. from sales metallurgist, Indianapolis, Ind., to salesman in the Philadelphia office.

Francis K. White, formerly general supervisor of the metallurgical laboratory of the Peoria, Ill., plant, Caterpillar Tractor Co., has been appointed plant metallurgist of the new plant at Decatur, Ill.

William R. Thurtle has resigned as metallurgist at Deere & Co., Moline, Ill., to accept a position as associate engineer at Boeing Airplane Co., Wichita, Kans.

Lester F. Spencer, formerly research metallurgist with the ferrous alloys division of the Naval Research Laboratory, Washington, D. C., is a research metallurgist for Allis Chalmers Mfg. Co., Milwaukee, Wis. Mr. Spencer has also served as chief metallurgist of Landers Frary & Clark, New Britain, Conn., and chief metallurgist of Diebold, Inc., Canton, Ohio.

John K. Anthony is an associate professor in the department of physical metallurgy in the College of Mines and Metallurgy at the University of Arizona.

D. Scott Bowman has moved to California as representative for the Globar Div. of Carborundum Co. Mr. Bowman had spent six years with the same company in Chicago before he was transferred to the West Coast.

Personals . . .

Geoffrey V. Raynor, head of the department of physical metallurgy, University of Birmingham, returns to England this month after fulfilling the visiting lectureship assignment. Dr. Raynor arrived here in September, and after a two-week lecture tour joined the 37th National Metal Congress and Exposition in Philadelphia, where he took part in the annual Seminar on the "Theory of Alloy Phases".

Walter T. Lowe is now employed by the U. S. Government as metal trades vocational educationist and is on a two-year tour of duty in the Philippines.

Anthony R. Ginnetti has been employed as a metallurgist by the Erie (Pa.) Forge Div., Kaiser Aluminum & Chemical Corp., since obtaining his bachelor's degree in metallurgy from Carnegie Institute of Technology in June.

John E. Hatch, works assistant chief metallurgist of the New Kensington, Pa., plant of the Aluminum Co. of America, has been transferred to the Davenport, Iowa, plant in the same capacity. At the same time, **R. W. Rogers**, staff metallurgist at Davenport, was transferred to New Kensington as works assistant chief metallurgist.

John C. Coonley was recently elected president of Hydraulic Press Mfg. Co., Mount Gilead, Ohio. Mr. Coonley was formerly general manager of the valve division of ACF Industries, Inc., Detroit.

Philip W. Snyder has been ordered from duty as Commander, Boston Naval Shipyard, to duty as U. S. Navy Shipbuilding Representative in Europe. Admiral Snyder will maintain headquarters in Paris.

S. S. Rice has been transferred by Ekco Products Co., from Chicago to the branch plant, The Autoyre Co., Oakville, Conn., as chief metallurgist.

Stanley W. Porembka, Jr. resigned from Battelle Memorial Institute, Columbus, Ohio, and is employed in the atomic power division of Westinghouse Electric Corp., Pittsburgh.

Personals . . .

S. L. Weaver, formerly district manager of sales, Latrobe Steel Co., Pittsburgh, has been transferred to Buffalo, N. Y., as district manager of sales for the New York territory.

Allen Kent has been appointed associate director of the newly created Center for Documentation and Communication Research at Western Reserve University. Mr. Kent was formerly principal documentation manager at Battelle Memorial Institute, Columbus, Ohio.

Paul E. Nelson, formerly quality control supervisor with Solar Aircraft Co., is now metallurgist in materials and processes department, airplane engineering division, McDonnell Aircraft Corp., St. Louis, Mo.

Bernard J. Freedman has resigned as supervisor, materials control laboratory, Pratt & Whitney Aircraft Corp., to accept a position as metallurgist with the Electric Boat Div., General Dynamics Corp., Groton, Conn.

Robert F. Mehl, director of the metals research laboratory at Carnegie Institute of Technology, was recently invited to give a series of lectures at the Royal School of Mines at the University of London. Dr. Mehl planned to extend his trip to visits to France, Germany, Holland, Norway and Sweden.

J. P. Warner has resigned from the staff of the University of British Columbia to accept the position of economist with Sherritt-Gordon Mines, Ltd., at the refinery at Fort Saskatchewan, Alberta.

Walter T. McCarty has resigned as senior instructor of mechanical technology at the State University of New York Agricultural and Technical Institute, Canton, N. Y., to take a position as project engineer in the reactor design section, atomic power division, Westinghouse Electric Corp., Pittsburgh.

Fred N. Singdale was recently transferred by Baldwin-Lima-Hamilton Corp., to California as manager of technical facility for the new West Coast division.

Personals . . .

William E. Daily has been promoted from chief chemist at Artcraft Fixtures Div., Special Products Co. of Tennessee, Fall River, Mass., to quality control manager of the company.

James M. Shilstone has moved from the Shilstone Testing Laboratory, New Orleans, La., to the Baton Rouge office, of which he is now the manager.

Leonard Smiley was recently appointed manager of technical coordination, atomic energy division, Sylvania Electric Products, Inc., Hicksville, N. Y.

Leon D. Michelove is now on active duty as second lieutenant with the U. S. Army Ordnance Corps, stationed at Fort Bliss, Tex.

Hartley R. Herman, formerly manufacturing planner at Rohr Aircraft Corp., Chula Vista, Calif., is now president of the Brown Corp., Ltd., Lemon Grove, Calif.

Philip Melara, supervisor of laboratories, Grumman Aircraft Engineering Corp., Bethpage, L. I., N. Y., is also now engaged as a consultant in metallurgy for Burgoyne Testing Laboratories, New Cassel, N. Y.

Peter C. Rossin, Jr. has been appointed research associate of Universal-Cyclops Steel Corp., Bridgeville, Pa.

Robert S. Morrow, past chairman of the Worcester Chapter, has been appointed sales representative of Universal-Cyclops Steel Corp., for the Worcester County and New Hampshire territories.

F. J. Dunkerley, for five years metallurgical consultant for Rolle Mfg. Co., Lansdale, Pa., has been named assistant general manager of the company. Holding B.S., M.S., and D.Sc. degrees from Carnegie Institute of Technology, Dr. Dunkerley spent four years at Battelle Memorial Institute, and served as professor of metallurgy at the University of Pennsylvania for ten years. He is also vice-president and general manager of Rolle Research & Testing, Inc., Hatfield, Pa., a division of the company.

Personals . . .

Clifford A. Hampel ⊕ has joined Fansteel Metallurgical Corp., North Chicago, Ill., as manager of the chemical equipment division. Mr. Hampel is a graduate of the University of Minnesota, and was formerly with Armour Research Foundation. He is the editor of "Rare Metals Handbook", and of the "Encyclopedia of Chemical Reactions".

Theodore Gela ⊕, formerly assistant professor of metallurgy at Stevens Institute of Technology, has been promoted to the rank of associate professor.

Guenther H. Hille ⊕ has been appointed sales engineer for the Mallory-Sharon Titanium Corp., Niles, Ohio. Mr. Hille graduated with a B. S. degree in metallurgy from the University of Wisconsin, and began his professional career in 1940 as a metallurgical engineer for the Ladish Co., Milwaukee, and was named assistant purchasing agent in 1948. In 1953 he joined the Salem Brosius Co., Pittsburgh, as director of purchases. He is a past chairman of ⊕ Milwaukee Chapter.

Erwin O. Deimel ⊕ has resigned as senior research metallurgist for Utica Drop Forge & Tool Corp., to accept a position as product design engineer in the light military electronic equipment department, General Electric Co., Utica, N. Y.

Robert B. Butler ⊕ has been appointed sales manager of AiResearch Industrial Div., Garrett Corp., Los Angeles. A veteran of 20 years with Oliver Corp., Chicago, Mr. Butler was head of the sales engineering activities for the Be-Ge Mfg. Co., an Oliver subsidiary at Gilroy, Calif. He is a graduate of the University of Nevada with a B. S. degree in mechanical engineering.

J. A. Cairns ⊕ has been appointed sales manager of Allied Research Sales Corp., Baltimore, Md. Mr. Cairns joined the Allied organization in 1948, and in 1951 was made district sales manager for the eastern Pennsylvania-northern New Jersey territory. In 1954 he was made manager of special projects in the home office in Baltimore.

Standardize your forging procedures—use TIMKEN® steel forging bars

60 chemical checks keep them uniform—order to order, heat to heat, bar to bar!

Etch testing of specimens in hydrochloric acid

NO need to change your forging procedures to fit each order of steel, when you use Timken® steel forging bars. Their quality is so closely controlled you can *rely* on their uniformity.

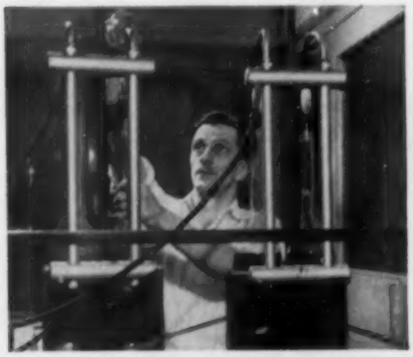
Every heat must undergo a series of *sixty* chemical checks that start with spectrographic analysis of the molten steel with the industry's first direct-reading spectrometer, and continue through to the final steps in manufacture.

This is one reason Timken steel forging bars have uniform physical and chemical properties, respond uniformly to heat treatment, have uniform grain size after heat treatment, and have good dimensional tolerances, too.

What's more, every order of Timken steel forging bars is "tailor-made" to meet your specific needs. Every subsequent order is matched to the first. And your order of Timken forging steel is handled individually in our mill and produced according to your specifications.

All this means you'll have fewer rejects, and less need to make furnace adjustments. You'll be working with steel of uniform high ductility and resistance to impact. With Timken steel forging bars, your forging procedures can be *standardized*.

Industry's first direct-reading spectrometer analyzes molten steel in 40 seconds



Some chemical tests require elaborate equipment

Our Technical Staff will help you choose the correct analysis for your forging job, based on their experience with many thousands of tough forging problems. Let us put your name on the subscription list for our technical bulletins on forging steels. They're free. Just write The Timken Roller Bearing Company, Steel and Tube Division, Canton 6, Ohio. Cable: "TIMROSCO".

Titrating to determine analysis of steel

YEARS AHEAD—THROUGH EXPERIENCE AND RESEARCH

SPECIALISTS IN FINE ALLOY STEELS, GRAPHITIC TOOL STEELS AND SEAMLESS TUBING

Personals . . .

R. J. Brown has been appointed materials engineer for the British Motor Corp., Longbridge, England. Mr. Brown joined Morris Motors in 1929 as a chemist, becoming chief chemist and metallurgist in 1935, and was placed in control of Nuffield Central Research Laboratories in 1945.

D. G. Boxall recently resigned as a senior scientific officer, nuclear metallurgy section, at the Canadian Dept. of Mines and Technical Surveys, to accept the post of metallurgist with the newly formed civilian atomic power department of Canadian General Electric Co., Peterborough, Ont.

A. C. Woolley has been named to the newly created post of manager of industrial service for Pacific Scientific Co., Los Angeles. "Doc" Woolley, who served as chairman of the Oregon Chapter in 1949-50, operated his own instrument service in Oregon prior to joining Pacific Scientific.

David W. Levinson, formerly a research metallurgist, has been appointed supervisor of nonferrous metallurgy research in the metals research department at Armour Research Foundation of Illinois Institute of Technology, Chicago. Dr. Levinson received his B.S. in chemical engineering in 1948, M.S. in metallurgical engineering in 1949, and Ph.D. in physical metallurgy in 1952, all from Illinois Tech.

John C. Emerline recently observed the 25th anniversary of his employment by Leeds & Northrup Co., Philadelphia, where he is a sales representative covering northern New Jersey. Mr. Emerline joined Leeds & Northrup in 1930 in the inspection department, and in 1935 was transferred to the sales department.

Louis A. Ringman has been appointed fabrications manager at the Claymont, Del., plant of the Wickwire Spencer Steel Div. of the Colorado Fuel and Iron Corp. Mr. Ringman was previously vice-president in charge of manufacturing for the Security Engineering Div. of Dresser Operations, Inc., Whittier, Calif.

Personals . . .

Paul Weber ⊕, professor of chemical engineering and director of the School of Chemical Engineering at Georgia Institute of Technology, has been appointed dean of faculties. Dr. Weber is a graduate of the South East Missouri State College (A.B., 1925), and obtained his M.S. in chemistry from the Missouri School of Mines in 1927. From 1927 to 1931, he served on the faculty of Georgia Tech as an instructor in chemical engineering. He obtained his Ph.D. from Purdue University, and returned to Georgia Tech as assistant professor, associate professor, and full professor. In 1948 he was named director of the School of Chemical Engineering at Georgia Institute of Technology.

W. C. Truckenmiller ⊕ has been appointed assistant technical director of Albion Malleable Iron Co., Albion, Mich. Mr. Truckenmiller is a graduate in metallurgical engineering from the University of Michigan. His experience includes supervisory positions with the A. C. Spark Plug Div. of General Motors, two years in the U. S. Naval Reserve, and 12 years as associate professor of production engineering at the University of Michigan.

Herbert Schwartz ⊕, formerly sales manager of the American Silver Co., is the new president and sales manager of Technion Design & Mfg. Co., Inc., New York.

James T. Parker ⊕ has joined Pickup Precision Gear Co., Costa Mesa, Calif., as sales representative on the Coast.

George J. Fischer ⊕ has resigned as director of the department of metallurgy of Sam Tour & Co., Inc., New York, to accept an appointment to the faculty of the Polytechnic Institute of Brooklyn as assistant professor in the department of metallurgy. At Sam Tour & Co., Mr. Fischer carried out metallurgical investigation, consulting, research, development and testing. He previously was associated with the Western Electric Co., Kearny, N. J., as plant metallurgist. In 1948 he was an instructor in metallurgy and materials testing at Brooklyn Polytechnic Institute.


4150 steel is your best bet for heavy sections
Chromium Molybdenum Steel like AISI-SAE 4150 is the most economical way to uniform properties throughout heavy sections. For heavy duty gears — for shafts — wherever toughness and fatigue strength are important, *plentiful* 4100 Moly steels are better. We will prove it. Climax Molybdenum Company, 500 Fifth Ave., New York 36, N. Y.
AISI-SAE 4150
C 0.48/0.53
Mn 0.75-1.00
Pmax 0.040
Smax 0.040
Si 0.20/0.35
Cr 0.80-1.10
Mo 0.15-0.25
4100 steels are your best bet
CLIMAX MOLYBDENUM

Soft Surfacing*

Soft surfacing by welding, like hard surfacing, consists of putting a coat of liquid metal on top of solid metal with a minimum of mixing. Cannon shells need soft bands on the outside to engage the rifling. These are usually made of copper or gilding metal, swaged into machined grooves in the shell body. Welding is better for a number of reasons; the rings are fused to the shells, bands can be put on thinner shells and iron can be used to save strategic materials. The following welding procesess were tried:

1. Inert - gas - shielded metal - arc with consumable electrode.
2. The same as No. 1, with a non-electrode or "cold" wire fed continuously into the puddle.
3. The same as No. 2, but using a-c. series arc with emissive coated electrode and an aluminum-coated cold wire.
4. Submerged-arc.

The second process was used for most of the tests even though softer iron could be deposited by the third and fourth processes. The cold wire was effective in increasing speed and cooling the puddle. This reduced penetration so that iron from the base metal could be held below 1½%. Because of its low boiling point zinc could be added only from the cold wire.

Wide bands were made by spiral welding, by step indexing and by a weave bead method. The weave bead technique was found to be the most economical and it reduced the cost of equipment since it was cheaper to oscillate the welding head than to provide a mechanism for index or spiral feeds. Overlay rotating bands of copper, silicon bronze, aluminum bronze and iron have been successfully welded to hot forged, heat treated shells. These bands have been applied to cold extruded shells and rocket motor bodies. It was frequently necessary to cool the projectile during welding to preserve its mechanical properties. This was done by injecting air or water into the shell cavity.

Extensive firing tests, fragmenta-

(Continued on p. 150)

*Digest of "Welded Rotating Bands", by Cecil C. Fawcett, *Ordnance*, July-August 1955, p. 172-176.

Soft Surfacing . . .

tion tests and tensile tests on specimens removed from beneath the weld showed no serious difference in the results from welded and unwelded shells. Some advantage might be gained from the fact that the welded bands were fused to the steel shells. Research and development involved many sizes ranging from .50 caliber to 11 in. diameter.

Military Specification No. MIL-W-13562 (ORD) covering welded rotating bands for projectiles has been written by Frankford Arsenal.

DAN WHITE

Al-Cu Sheet Alloys With Cd Additions*

SMALL percentages of cadmium, indium or tin exert a pronounced influence on the response to artificial age hardening of aluminum-copper alloys and do not interfere with hot workability. Cadmium is the most effective addition from a practical standpoint since its action is not inhibited by small quantities of magnesium and because undissolved cadmium does not affect the ductility of the alloy at room temperature or cause hot shortness.

In this latest report on the effects of cadmium additions, three groups of alloys were studied. One was cadmium-free, containing 4.37% Cu, 0.21% Si, 0.1% Fe, 0.58% Mn and traces of Ti and Mg. A second had 0.097% Cd, with 4.27% Cu and the remaining elements approximately the same as in the first group. The third group contained 0.14% Cd and 5% Cu, other elements the same except for Si, which was 0.09%. Cast billets were hot rolled to 0.25 in. thickness, and given three intermediate anneals in the process of cold rolling to final gage – 0.036 in. for the higher cadmium alloys, 0.048 in. for the others.

Introduction of cadmium caused three principal effects when the alloys were artificially aged following

(Continued on p. 152)

*Digest of "Aluminium-Copper-Cadmium Sheet Alloys", by H. K. Hardy, *Journal of the Institute of Metals*, Vol. 83, February 1955, p. 337-346.

UNICHROME
Trade Mark

News about

COATINGS for METALS

Metallic . . . . Organic . . . . Decorative . . . . Protective

Copper plating process adapts to various needs

Plating processes matched for better finishing

The first matched set of plating process for a copper-bright nickel-chromium plate now exists to help engineers reduce finishing expense. Three integrated Unichrome processes work outstandingly well together, each deposit contributing to the end result – an outstanding chromium finish.

Equally important are the extra advantages of the individual processes. For example:

IMPROVED NICKEL

Deposits from Unichrome Bright Nickel prove unusually receptive to the subsequent chromium. Having low internal stress, the deposits resist cracking and give excellent corrosion protection to the base metal. The remarkably stable solution has also reduced operating problems.

MORE EFFICIENT CHROMIUM

Wider bright plating range and higher efficiency of Unichrome SRHS Chromium Solutions deliver many benefits. Capacity of existing equipment goes up, plating time is often cut more than half, more intricate parts can be successfully covered, and users often report finishes with better "color."

Contact the nearest office of United Chromium for details.

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Non-cyanide Unichrome Pyrophosphate Copper Process provides deposits of unusual nature—users benefit

Two of the finishes obtainable with Unichrome Copper. Left: Lustrous plate that needs no buffing prior to bright nickel (Courtesy Royal Plating and Polishing Co., Inc., Newark, N. J.). Right: Satin deposit (upper portion of steel part) that buffs fast and easy to a high color (shown on lower portion of part).

There are big differences in the deposits obtained from copper plating solutions. The differences encompass smoothness, ductility, buffability, lustre, and density of deposit.

In the case of the Unichrome Pyrophosphate Copper Process, the plate can be controlled to suit a number of production needs exactly. Newly perfected addition agents, when added to the basic bath, alter the deposit without detracting from its time-proved features.

TO BUFF OR NOT TO BUFF

With one agent, a lustrous deposit is produced which can eliminate buffing. With another, a satin finish is produced which is ideal for buffing – permitting buffing of the free-flowing, ductile copper rather than base metal or subsequent nickel plate.

SMOOTHNESS IS BASIC

Whether used with or without the addition agents, Unichrome Copper deposits are noted for their essential smoothness. In addition, the plating bath has good leveling action, and produces unusually fine grained deposits.

STOP-OFF SERVICE

Metals engineers have long made good use of the deposit characteristics of Unichrome Copper for stop-off work in nitriding and carburizing operations. Because of the density and fine grain of Unichrome Copper, dependable masking is secured with thinner deposits, thereby saving plating time and money.

COMPATIBLE DEPOSITS

Unichrome Copper contributes also to better and more economical copper-nickel-chromium finishing. Its deposit proves ideally receptive for nickel plating, avoiding passivity problems and need for activation treatments.

Send for more detailed information.

Al-Cu Sheet Alloys With Cd Additions . . .

solution treatment for 30 min. at 990° F. First, tensile strength was much higher than that obtainable in the absence of cadmium. Second, although tensile strength of the Al-Cu alloys is improved by cold work before aging, the reverse is true for Al-Cu-Cd alloys. Third, the resistance to stress-corrosion of the artificially aged alloys is greatly increased by cadmium.

Additions of Cd, In or Sn probably owe their influence on elevated-temperature aging of Al-Cu alloys to some type of nucleation process. Cold work might interfere if it caused rapid precipitation in a form incapable of affecting the decomposition of the Al-Cu solid solution. Tensile properties obtained with the cold worked and artificially aged Al-Cu-Cd alloys would appear to represent a balance between the softening due to effective removal of Cd and hardening due to the normal nucleation effect of cold work.

The effect of pre-aging before cold reduction may be to produce "ternary" nuclei, so that the precipitation process does not change back to that of the Al-Cu alloy without cadmium. Enhanced general precipitation in the alloy with cadmium reduces the possibility of a thin, continuous anodic path around the grain boundaries. Consequently stress-corrosion attack is predominantly intercrystalline and a fully aged sheet (6 hr. at 355° F. or 16 hr. at 330° F.) has excellent stress-corrosion resistance. This type of corrosion may occur in material only partially aged when the intercrystalline attack results from the difference in solution potential between the relatively undecomposed grain centers and the anodic grain-boundary regions depleted in copper by precipitation.

The Al-Cu alloy without Cd gave inferior resistance even when aged to yield peak properties (40 hr. at 330° F.). However, both types of alloys exhibited excellent resistance when fully aged after cold work. Stress-corrosion tests were carried out on transverse test pieces stressed as horizontal cantilever beams and sprayed daily with 3% solution of NaCl. A. H. ALLEN


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LIGHT WEIGHT . . . LONG WEARING . . . STRONG
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ANNEALED
TEMPERED
Meets every requirement for modern product design and fabrication. Excels in accuracy, ductility, hardenability, finish, high fatigue value, and uniformity.
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WALLACE BARNES COMPANY • Bristol, Conn.
DIVISION OF ASSOCIATED SPRING CORPORATION

Catastrophic Oxidation by V_2O_5*

IN ALLOYS for gas turbines, the criterion has generally been high-temperature creep strength. Scaling resistance usually proved to be quite satisfactory except when residual oils were used for fuel and these oils contained vanadium compounds. Vanadium pentoxide in the fuel ash often causes a catastrophic increase in corrosion.

Messrs. Harris, Child and Kerr studied the effect of alloy composition on its resistance to scaling, by exposing alloys of widely varying Ni-Co-Cr-Fe content, to hot atmospheres, both with and without V_2O_5 contamination. Vanadium pentoxide always and markedly accelerated corrosion above 1400° F. – which isn't very hot by jet engine standards. Nevertheless, it has been found that the composition does have some influence; specific requirements must be met to obtain an austenitic material which provides maximum resistance to V_2O_5 attack. For example, if the chromium is held constant at 20% and the nickel, chromium and iron ratio varies over the entire range, there is little change in the amount of metal lost regardless of the change in composition if the metal is exposed to air at 1750° F. (The actual loss varies from 1.0 to 4.4 mg. per sq. cm. per hr.). However, if exposure is at 1560° F. and the air contains V_2O_5, some alloys of low resistance were found. Outside this range of composition the loss of metal varies from 2.7 to 6.0 mg. per sq. cm. per hr., but within the composition range of low resistance the metal lost from 60.2 to 82.0 mg. per sq. cm. per hr. These susceptible compositions include the approximate range from 12 to 32% nickel, 38 to 63% iron, and 0 to 18% cobalt (chromium content remaining constant at 20% as noted above). If other carbide-forming elements – namely 3% W, 3% Mo, and 3% Cb – are added to the 20% chromium

(*Continued on p. 156*)

*Digest of "Effect of the Composition of Gas Turbine Alloys on Resistance to Scaling and to Vanadium Pentoxide Attack," by G. T. Harris, H. C. Child and J. A. Kerr. *Journal of the Iron and Steel Institute*, Vol. 179, March 1955, p. 241.

Tool Steel Topics

BETHLEHEM STEEL COMPANY, BETHLEHEM, PA.

Production Up 50 pct with Bearcat Riveting Tool

For some time a manufacturer had been using a tool made of alloy steel, 2⅛ in. round, to cold-rivet weight-lever sets, 1 7/16 in. sq, for railroad switch stands. The tool was used in a series of rotating blows, average production being 70 pieces per tool before redressing was required.

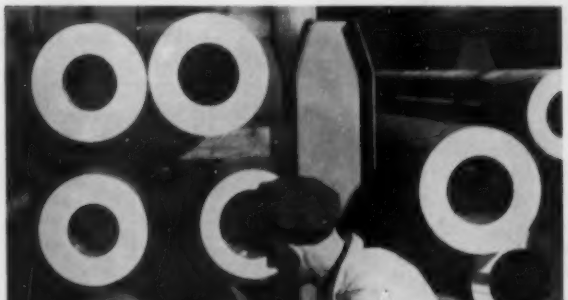
As the operation clearly called for steel with exceptional resistance to shock and wear, we suggested, "Why not give Bearcat a trial on that job? Bearcat's got the toughness you want. What's more, we wouldn't be surprised if it gave enough longer life to bring down your costs."

They made the change, with the result that tool life increased about 50 pct.

Bearcat is a tough, general-purpose grade of air-hardening tool steel. It has exceptional resistance to shock, and superior wear-resistance. Its air-hardening characteristic minimizes quenching hazards, and also provides good resistance to distortion in heat-treatment.

In addition to cold-riveting tools, there are many other applications in which Bearcat gives a good account of itself —in such tools, for example, as chisels, gripper dies, master hobs, hot headers, and die-casting die inserts.

Why not look into Bearcat? You can obtain full information from your Bethlehem tool steel distributor.



Save Time with Hollow-Bar in Ring-Type Applications

If you use draw rings, hardened bushings, ring dies or the like, you'll find you can save time in the shop with Hollow-Bar Tool Steel. Bethlehem Hollow-Bar comes in two types: BTR (oil-hardening) and Lehigh H (high-carbon, high-chrome). It's made by a high-speed trepanning process, which cores out the inside diameter of hammer-forged or hot-rolled, rough-turned bars. Hollow-Bar goes to work for you immediately. There's no waiting for forged rings or discs — nor are drilling, rough boring or facing, or rough turning required. Just think of the time that saves!

BETHLEHEM TOOL STEEL ENGINEER SAYS:

Here's a Quick Look at Short-Run Dies

There are many types of dies used for blanking or forming where the production required may be only a few hundred pieces, or less. Such requirements occur frequently, as in the aircraft industry, for example. In such circumstances, the normal procedure of machining a die, then heat-treating and grinding it (to produce a die good for millions of parts) is neither practical nor economical. What is desired is a steel which can be machined to size, then used immediately.

One of our standard grades which is ideal for this application is Brake Die Tool Steel. Brake Die comes in rounds, squares and flats. It is a free-machining steel, and has been heat-treated at the mill to the highest hardness possible consistent with good machinability. On forming operations, dies made of Brake Die will last for tens of thousands of parts. And on blanking operations, it will produce anywhere from a few hundred parts to a few thousand, depending of course upon the type of material being blanked, and its thickness.

Catastrophic Oxidation by V_2O_5 . . .

base, all alloys containing more than 40% iron become very susceptible to catastrophic attack by V_2O_5.

Another series of tests showed that, while a large proportion of chromium was very effective in reducing the corrosion rate in air, it was much less effective in the presence of V_2O_5.

Previous studies had indicated that molybdenum additions may cause a similar increase in the corrosion rate of heat resistant steels. On the other hand, the experiments under review show that molybdenum up to 9% could be added to a low-carbon, 20% Ni, 20% Co, 20% Cr alloy without increasing the corrosion rate at high temperature. The authors conclude that for alloys rich in nickel, cobalt, and chromium, additions of molybdenum, columbium, and titanium have no pronounced deleterious effect on scaling resistance at 1750° F. in still or moving air. However, in iron-base alloys, molybdenum additions are quite harmful and cause a greater attack in still air than moving air.

For an alloy which is most resistant to contamination by vanadium pentoxide the iron should be less than 30%, chromium at least 16%, and vanadium (in the alloy) should not exceed 2%.

If iron content must be greater than 30% the desirable composition range is about 16% Cr or more, 0 to 10 *or* more than 40% Ni, less than 0.5% V and less than 3% Mo.

GEORGE W. CUNNINGHAM

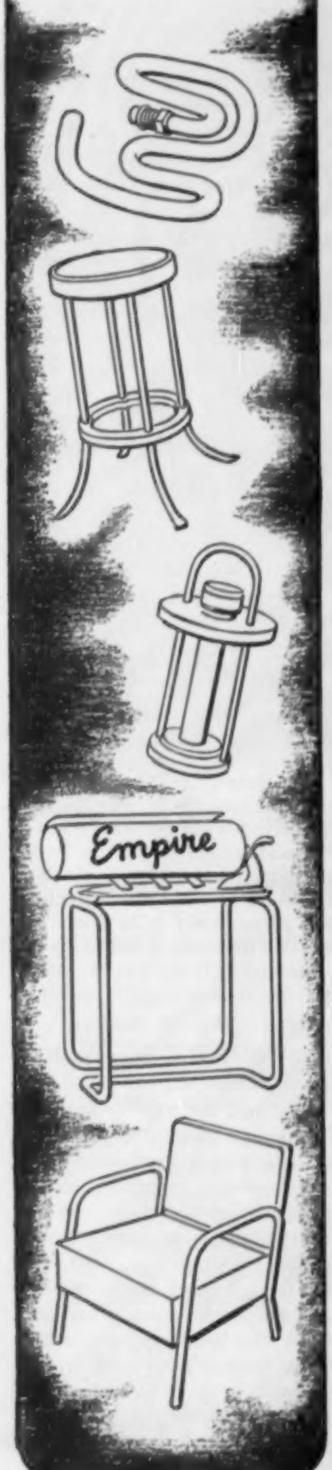
Effect of Oxide Surface Layers on Creep*

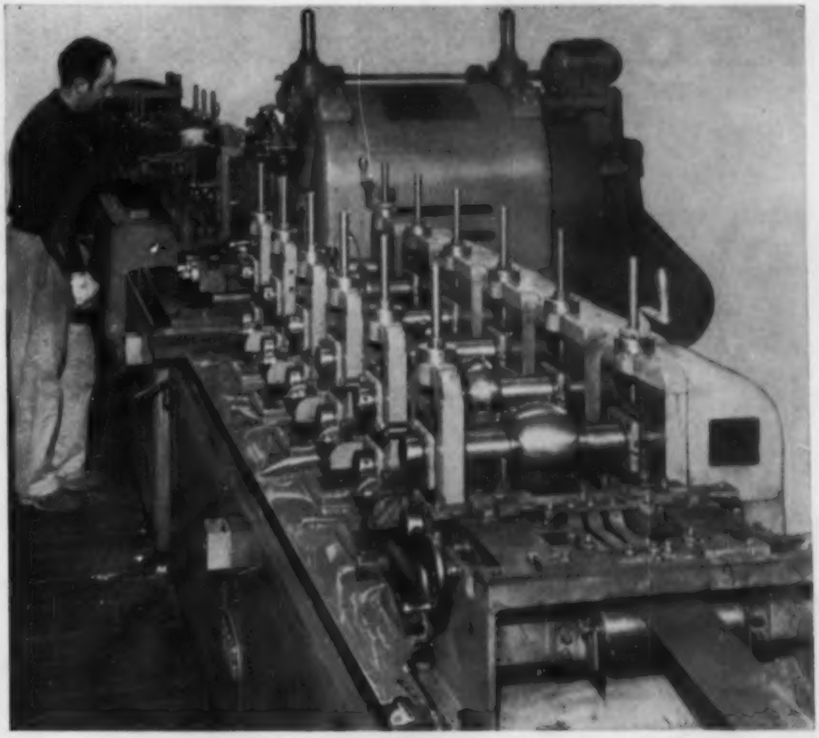
IN 1928 Rebinder established the general phenomenon of the facilitation of deformation and of rupture of solid bodies through the influence

(Continued on p. 158)

*Digest of "Influence of Oxide Films on the Effect of Adsorptive Facilitation of Deformation of Metallic Single Crystals", by V. N. Rozhanskii and P. A. Rebinder, *Doklady Akademii Nauk SSSR*, Vol. 91, 1953, p. 129-131.

(Right) Yoder M-2½ Tube Mill installed by James Steel & Tube Co., Van Dyke, Mich. for making tubing sizes from ½" to 2½" o.d., incl.





Plain Facts about

ELECTRIC-WELD TUBE MANUFACTURE

In tube making everybody wants the highest possible speed consistent with good, strong welds and dimensional accuracy. There are, in addition, at least three more essentials to profitable tube making, namely:

1. Low scrap losses—because cost per foot of strip metal is many times greater than the conversion cost.
2. Fine exterior finish, free from scratches, scuff marks and other irregularities which limit usefulness and lower salability.
3. Quick and easy mounting and adjustment of tooling, to reduce time losses between successive production runs.

Yoder tube mills excel in all these respects and have other mechanical, electrical and economic advantages. Because Yoder tube mill owners have found from experience their performance is as good as our promise, there are more Yoder mills sold and in operation than all other electric-weld mills combined. This is as true today as it was ten years ago.

If you want the plain facts about the things to look for in a tube mill, to insure most profitable operation over the years, the new Yoder Tube Mill Book will give them to you, in the simplest language and with numerous illustrations.

A copy is yours for the asking.

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COLD ROLL FORMING PRODUCTION LINES

INGENIERÍA YODER MANUFACTURA

Effect of Oxide Surface Layers on Creep . . .

of adsorbed surface layers. During the past few years there has been increased interest in this phenomenon, especially with regard to metal single crystals. Andrade found that he usually observed a weakening effect of adsorption only on single crystals that were covered by an oxide layer but not on cleaned crystals. Since the strengthening action of an oxide layer is relatively weak, this observation could not be explained in terms of an elimination of this action by the adsorbed substance. On the other hand, both Masing and Rebinder showed that the effect of adsorption in increasing the creep rate of metals followed

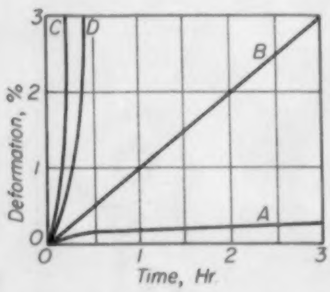


Fig. 1 – Creep of Single Crystals of Tin Having an Oxide Layer, With the (110) [001] Slip System Oriented So That $\chi_0 = 60^\circ$, $\lambda_0 = 69^\circ$, Under a Load of 390 Psi. Tests were made in (A) vacuum; (B) an atmosphere of ethyl alcohol vapor with a pressure of 1×10^{-3} mm. of mercury; (C) same, but 1 mm. of mercury; (D) 25 mm. of mercury. All specimens 0.79 in. long

some of the laws of electrocapillary phenomena and so was related to the metal and not to an oxide film.

The present method of investigation was to expose single crystals of tin undergoing a creep test to the vapor of ethyl alcohol under reduced pressure. Specimens were tested both with the oxide film, 2000 Angstroms thick, formed during production of the single crystals, and also after the film had been removed by cathodic bombardment with hydrogen ions in a glow-discharge tube. The specimens were 0.5 mm. (0.02 in.) in diameter and 6 to 20 mm.

(Continued on p. 160)

From Vacuum Melting—improved alloys with exceptional properties

. . . greater UNIFORMITY, for example

Vacuum-melted metals introduce a new standard of uniformity. For the nonmetallic inclusions that limit an alloy's optimum performance are almost entirely eliminated. Result: higher production and inspection yields . . . improved fabrication characteristics . . . better electrical conductivity . . . greater physical uniformity.

High-vacuum melting literally sucks gaseous impurities from the molten metal . . . makes possible high-purity metals with properties unattainable by any other commercial method. Jet engine turbine blades give more than *twice* the performance life of similar blades of conventional air-melted alloys. And here's another example—rejections of high-speed, heavily loaded bearings dropped from 50% to 3% when vacuum-melted metals were used.

Now, you can get these unique new metals for your applications. For Vacuum Metals Corporation, pioneer in development and leading producer of vacuum-melted metals, has them available in tool, high-speed, stainless and alloy steels—in most sizes and grades—as well as special ferrous and nonferrous alloys. If you have a metals problem that vacuum-melted alloys might solve, please describe it in as much detail as possible. Write *Vacuum Metals Corporation, P. O. Box 977, Syracuse 1, N. Y.*

VMC

VACUUM METALS CORPORATION

Jointly owned by Crucible Steel Company of America and National Research Corporation

Effect of Oxide Surface Layers on Creep . . .

(0.24 to 0.79 in.) long. In analyzing the creep data obtained on the single crystals, comparisons were made only among specimens that had the same orientation of the crystal axes to the specimen axis.

It was found that the change in creep rate produced by a given vapor pressure of ethyl alcohol (compared to the creep rate in vacuum) was greater the larger the creep stress. Therefore, relatively large stresses were used. Figure 1 shows the results obtained with a stress of 275 g. per sq. mm. (390 psi.) acting on single crystals of tin covered with an oxide film. Ethyl

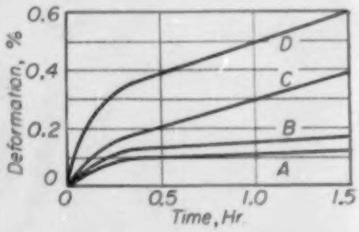


Fig. 2 – Creep of Single Crystals of Tin Without an Oxide Layer for Specimens of Various Lengths, With the (100) [011] Slip System Oriented So That $\chi_0 = 25^\circ$, $\lambda_0 = 30^\circ$, Under a Load of 210 Psi. (A) 0.79-in. specimen in vacuum; (B) 0.79-in. specimen in an atmosphere of ethyl alcohol vapor at a pressure of 1 mm. of mercury; (C) 0.32-in. specimen in vacuum; (D) 0.32-in. specimen with conditions same as (B)

alcohol vapors at a partial pressure of 25 mm. of mercury increased the creep rate 100 fold. On the other hand, experiments on single crystals relatively free of oxide film failed to show much effect.

Tests of media other than ethyl alcohol gave the following results: Nonpolar substances, such as pentane, had no effect. With increasing vapor pressure of ethylamine the acceleration of creep rate passed through a maximum and then decreased somewhat. Water vapor caused an increase in creep rate in proportion to its pressure.

Shorter specimens, in which there is a greater tendency toward a non-

(Continued on p. 162)

Effect of Oxide Surface Layers on Creep . . .

uniform stress state, showed both a higher creep rate and a somewhat greater sensitivity to surface-active substances. These phenomena are illustrated by the data of Fig. 2 for unoxidized specimens and Fig. 3 for single crystals with an oxide layer.

It was concluded that the role of the oxide layer in the facilitation of

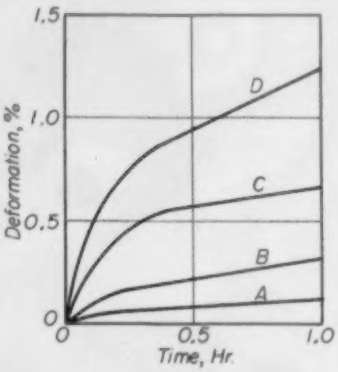


Fig. 3 – Creep of Single Crystals of Tin Having an Oxide Layer for Specimens of Various Lengths, With the (100) [011] Slip System Oriented So That $\chi_0 = 44°$, Under a Load of 280 Psi. (A) 0.79-in. specimen in vacuum; (B) 0.79-in. specimen in an atmosphere of ethyl alcohol vapor at a pressure of 1 mm. of mercury; (C) 0.24-in. specimen in vacuum; (D) 0.24-in. specimen, same conditions as (B)

creep by surface-active substances is the creation of nonuniform stress states. The oxide layer breaks in a brittle manner in a ring pattern and causes concentration of stresses. The local acceleration of deformation somewhat relieves the stresses under the ring, and generally this may either strengthen or weaken the metal. In practice, the potential sources of weakness (defects) in the metal surface are activated in this manner, and the higher creep rate results. A. G. Guy

Fe-Cr-Al Alloys for High Temperatures*

THE GOOD oxidation resistance combined with low absorption of thermal neutrons of 25% Cr, 5% Al electrical steel would make it attractive for atomic energy applications if its strength at elevated temperature were higher. To improve its strength at 2200° F. without impairing oxidation resistance, Battelle Memorial Institute investigated a series of iron-chromium-aluminum alloys with a wide variety of alloy additions.

Preliminary work involved melting, rolling and oxidation testing of a number of iron alloys containing 5 to 43% Cr and 5 to 12% Al. They were melted in helium atmosphere with a tungsten electrode. Crucibles were water-cooled copper blocks. The alloy buttons were remelted 4 to 6 times and turned over each time to insure homogeneity. Before rolling, the buttons were annealed 18 to 20 hr. at 1800 to 2200° F. In rolling, each pass gave 5 to 20% reduction and was followed by reheating. The product was strip 0.07 in. thick. For good rolling, the Cr content plus 3 times the Al had to be less than 65%.

The oxidation test specimens ($0.055 \times 0.5 \times 1$ in.) were finished on 400-grit emery paper, cleaned, dried with acetone and weighed. Two kinds of oxidation tests were made in triplicate in an open Globar furnace. In one, the specimens were held 100 hr. at 2200° F.; in the other they were held 15 min. at 2200° F., then 15 min. at 850° and so on for 200 cycles. After exposure each specimen from the constant-temperature test was weighed together with any spalled oxide to determine the gain in weight. Metallographic specimens from both kinds of tests were also examined to evaluate oxide penetration.

All the ternary alloys were free from pitting and intergranular oxidation at 2200° F. Alloys with 5 to 6% Al resisted surface oxidation at 2200° F. (less than 0.02 g. per sq. in. gain in 100 hr.) if they contained

*Digest of "Investigation of Wrought Iron-Chromium-Aluminum Alloys for Service at 2200° F.", by H. A. Saller, J. T. Stacy and N. S. Eddy; BMI-922, U. S. Atomic Energy Commission, June 1954, 45 p.

15% or more chromium. With 10% Al, only 5% Cr was needed. On the basis of these results and data in the literature, the 25% Cr, 5% Al composition was selected for testing the effects of other alloy additions.

These other alloys included Be, Mg, Si, misch metal with 45% Ce, Cu, Ag, Y, Ti, Zr, Cb, Ta, V, Mo, W, Mn, and Pd. Mg and Ag did not alloy with the Fe-Cr-Al base and no results with them are reported. A number of complex alloys with more than one addition other than Cr and Al were also made and tested. The alloys containing 1 to 5% Ce or 5 to 20% Cu alone were not rolled successfully, but one with 5% Ce and 1% Cu was rolled and tested. Alloys with 3% or more Be, 30% or more Cb, 20% Mn, 10% Si, 20% Ti, 20% V, or 3% or more Y failed in rolling and were not tested. Alloys with smaller additions than those noted were practical, however, and were tested. Oxidation tests on the complex alloys were made in the same manner.

The results of the oxidation tests showed that 1% Be, and 10% Mo, W, Ti, Zr, or V are impractical as alloy additions in this Fe-Cr-Al base material because of serious impairment to oxidation resistance at 2200° F. Additions of 10% Mn, or 5% Mo, W, Si or Pd, or 1% Y did not alter appreciably the rate of scale formation. Additions of up to even 20% of Cb or Ta also did not impair the oxidation resistance. About 2 to 3% Si improved the oxidation resistance of quarternary alloys containing Mn or Ta, and 1% Cu similarly improved the alloy containing 5% Cb. More complex alloys generally had poorer oxidation resistance, as did also Type 310 stainless steel, and an Fe-Cr-Al-Co alloy.

The high-temperature strength was measured by both short-time and long-time tests. In the short-time tests the specimens were held 15 min. at the desired temperature in air, then progressively loaded until sustained elongation was detected. The time for rupture at that stress, generally about 30 min., was measured. The long-time tests were made in the usual way at constant load and temperature (usually 2200° F.). The extension was measured with an external dial gage.

Tantalum strengthened the alloys

(Continued on p. 166)

Fe-Cr-Al Alloys . . .

very effectively; a 5% addition raised the 100-hr. rupture strength at 2200° F. from about 100 to 310 psi., and 10% raised it to 420 psi. Other additions with Ta did not give any improvement. The 100-hr. rupture strength with 5% Cb instead of Ta was only 280 psi., but the creep strength was about the same for both alloys. (Stress for minimum creep rate of 1% per hr. at 2200° F. was 400 psi. for 5% Ta and 420 for 5% Cb; or for rate of 0.01% per hr., 240 for 5% Ta and 210 for 5% Cb.)

The 100-hr. rupture strength was also improved by Be, W and Mo, 1% Be being as effective as 5% Ta. The alloys containing these elements instead of Ta or Cb had lower short-time rupture strength (960 vs. 1100 psi. at 2200° F.) or creep strength. Beryllium cannot be used because of its bad effect on the oxidation resistance. Palladium seems promising on the basis of short-time strength at 2200° F., but no long-time tests of a Pd alloy are reported. The high-temperature rupture strengths of the best of these alloys are inferior to those of Type 310 stainless steel or Inconel but the creep strengths are about the same.

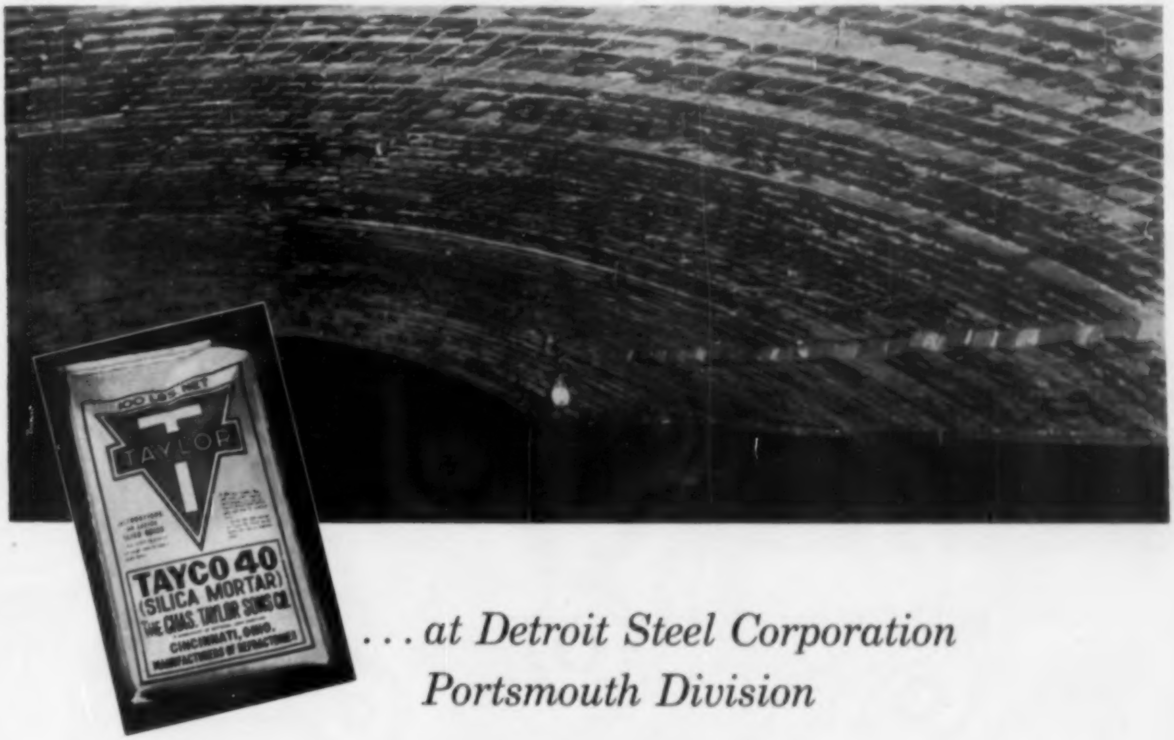
Tests of the 25% Cr, 5% Al alloys with and without Ta or Cb were made for dimensional stability at high temperatures in strip form. No appreciable changes were found after 100 hr. at 1800 or 2200° F., but after 200 half-hour thermal cycles between 850 and 2200° F. the quaternary alloys containing 5 or 10% Cb showed 5 to 6.4% growth, while those containing 10 or 20% Ta showed 1.7 to 4.7%, and the ternary Fe-Cr-Al alloy showed 0.3 to 1.5%.

Cold-bend tests were made on ⅜ × ⅜-in. specimens of strip of some of these alloys with a V-die and punches of different radii. The smallest radius was found that would give a 105° bend without cracking. The 25 Cr, 5 Al ternary alloy was fairly ductile as hot rolled, very ductile after water quenching from 1300, 1650, or 2000° F., but brittle when furnace-cooled from 2000° F. All the alloy additions produced embrittlement. Be, Mo and W gave the least embrittlement, especially

(Continued on p. 168)

Tayco 40 BONDS THE ROOFS...

Photograph courtesy of Detroit Steel Corporation



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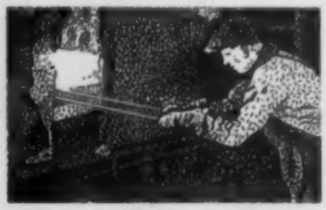
Fe-Cr-Al Alloys . . .

after quenching from 1300° F. Ta and Cb impaired the bend ductility seriously and it wasn't improved by heat treatment. However, an alloy containing 10% Ta, 4.6% Ti and 5.4% Si (with 25% Cr and 5% Al of course) was very nearly as ductile as the ternary-base alloy after quenching from 2000° F.

For micro-examination the best results were obtained by alternate polishing and etching in a water-cooled bath consisting of 1 part HNO_3, 1 part H_2O_2, 2 parts HCl and 2 parts glycerol. The ternary-base alloy was very coarse-grained as rolled or heated at 2200° F., with grams more than 1 mm. in diameter. After rolling at 1300° F. the structure was finer. A phase of unknown composition occurred in fine particles at the grain boundaries. Additions of up to 1% Be, 10% Mn, 5% Si, 5% Mo, or 5% W did not change the microstructure. A second phase was produced by 5 or 10% Ti, Cb, or Ta, with a decrease in grain size. Twelve micrographs are exhibited, and the second phase appears to occupy nearly half the field in those of the alloys containing 20% Cb or Ta. This second phase is presumably the cause of the poor bending quality of the Cb or Ta alloys.

It is concluded that the best addition to the 25 Cr, 5 Al, 70 Fe alloy is 10% Ta (replacing 10% Fe). This modification has the same excellent oxidation resistance at 2200° F. as the ternary-base alloy with 100-hr. rupture strength four times as great. The formability and dimensional stability during thermal cycling are impaired by the Ta addition.

No strength, formability or stability data are reported for the 25 Cr, 5 Al alloys containing 10% Mn or 5% Si, although these additions gave alloys that rolled well and had good resistance to oxidation. No discussion is offered as to why their high-temperature strength was not determined. G. F. Comstock



Cause of Flakes in Steel*

FLAKES are small internal cracks in steel ingots or forgings which are not related to segregates, microstructure, or shape of the piece. Internal stresses in flaky steel are thought to be small; *large* internal stresses lead to "quench cracks", larger than flakes, often reaching the surface, and related to shape of the piece or to the cooling methods.

Two theories about flake formation are held, the older one that they are caused by stresses set up by hydrogen coming out of solution in the cooling metal and collecting in very small voids – briefly, to hydrogen. The second theory holds that flakes result from stresses due to volume changes as the austenite transforms – briefly, to transformation stress.

Messrs. Dana, Shortsleeve and Troiano believe that their tests show that *both* hydrogen and transformation stress are necessary; hydrogen is the embrittling agent and transformation stresses cause the cracks.

For example, parallel tests were made on 1¼-in. rounds of various alloy steels (2340, 3140, 4140, 4340, 5145) wherein bars were austenitized in nitrogen atmosphere and therefore quite low in hydrogen, and others in hydrogen atmosphere and therefore having at least 5 cc. H_2 per 100 g. No flakes were found in the low-hydrogen bars after sectioning and electropolishing. These bars were heat treated in various ways which produced flakes in the high-hydrogen bars. Furthermore, when 1¼-in. hydrogenated rounds were end-quenched and sectioned longitudinally, certain regions along the length would be flaky and other regions of different cooling rates would be sound–there being no significant differences in the hydrogen analyses along the bar. Finally, decarburized surface layers had different susceptibility to flakes than the underlying metal; little difference in hydrogen existed, edge to center, but the transformation products (and stresses during formation) were quite different.

A large number of isothermal heat treatments reinforce the authors' conclusion above stated. When 4340 steel (1.75% Ni, 0.85% Cr, 0.25% Mo) is soaked 60 hr. in hydrogen at 2050° F. and isothermally transformed at 1170, flakes occurred in all pieces which were cooled from 1170° before the sample was *completely* transformed to ferrite and pearlite. At any shorter time, some retained austenite transformed on cooling or during room-temperature aging for one week, and the stresses induced by volume changes flaked the steel already embrittled by the hydrogen.

No cracks were obtained in steels transformed various times at 860° F. into various proportions of martensite and "upper bainite". The authors suppose that any subsequent

(Continued on p. 172)

*Digest of "Relation of Flake Formation in Steel to Hydrogen, Microstructure and Stress", by A. W. Dana, Jr., F. J. Shortsleeve, and A. R. Troiano, *Journal of Metals*, August 1955, p. 895.

Flakes in Steel . . .

transformation of the bainite sets up very small internal stresses. Further studies are under way, for they suspect that size of specimen may have some influence.

Finally, flakes appeared in all specimens isothermally transformed at 640° F. unless time was sufficient to produce the equilibrium microstructure, ferrite plus cementite.

REVIEWER'S COMMENTARY – In their summary the authors remark that "under appropriate conditions, abnormally high hydrogen contents may be tolerated without flaking". To this reviewer it would appear that such "conditions" would prevent a deep hardening alloy steel high in hydrogen from being of much industrial or military use, since it could not be heat treated to optimum mechanical properties without flaking or being dangerously close to incipient flaking. The authors have done useful service in emphasizing that steel with hydrogen in solution or containing hydrogen gas in vacancies or microscopic voids is inherently brittle and that stresses due to normal transformations are sufficient to flake it. They have also reinforced the findings of successful makers of gun tubes and large forgings that the way to avoid flakes is to make low-hydrogen steel with *dry* ingredients and fluxes, and to give any hydrogen which does get into the liquid ample chance to get out of the solid by cooling ingots and billets at a very slow rate from 700° F. down, where hydrogen solubility drops rapidly. E. E. T.

Automatic Production*

AT THE automation meeting in San Francisco, 13 notable speakers gave their opinions on recent technical progress in that field and what it is doing to business, including the economic and social implications. The talks were infused with a gen-

(Continued on p. 174)

*Summary of the proceedings of a symposium on "Electronics and Automatic Production" in San Francisco, August 22 and 23, 1955, sponsored by Stanford Research Institute of Menlo Park, Calif. and National Industrial Conference Board, Inc. of 247 Park Ave., New York City.

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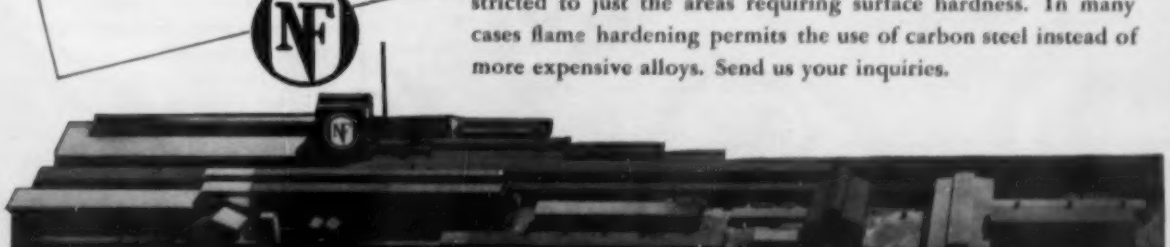

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Automatic Production . . .

eral feeling of confidence that at last we are to succeed in having an orderly industrial evolution wherein the mistakes of the past era of industrial revolution with its conflicts and work stoppages are to give way to a new era of continued progress.

For many people, automation, by whatever name it may be called, is a frightening thing. They do not see and they cannot imagine the prosperity, comfort and increased standard of living which it promises. They see only that the old order is changing and they fear the unknown effect on their jobs and their security. But the speakers at this forum believe that history has offered pretty convincing proof that we have no real need to fear the effects of progress.

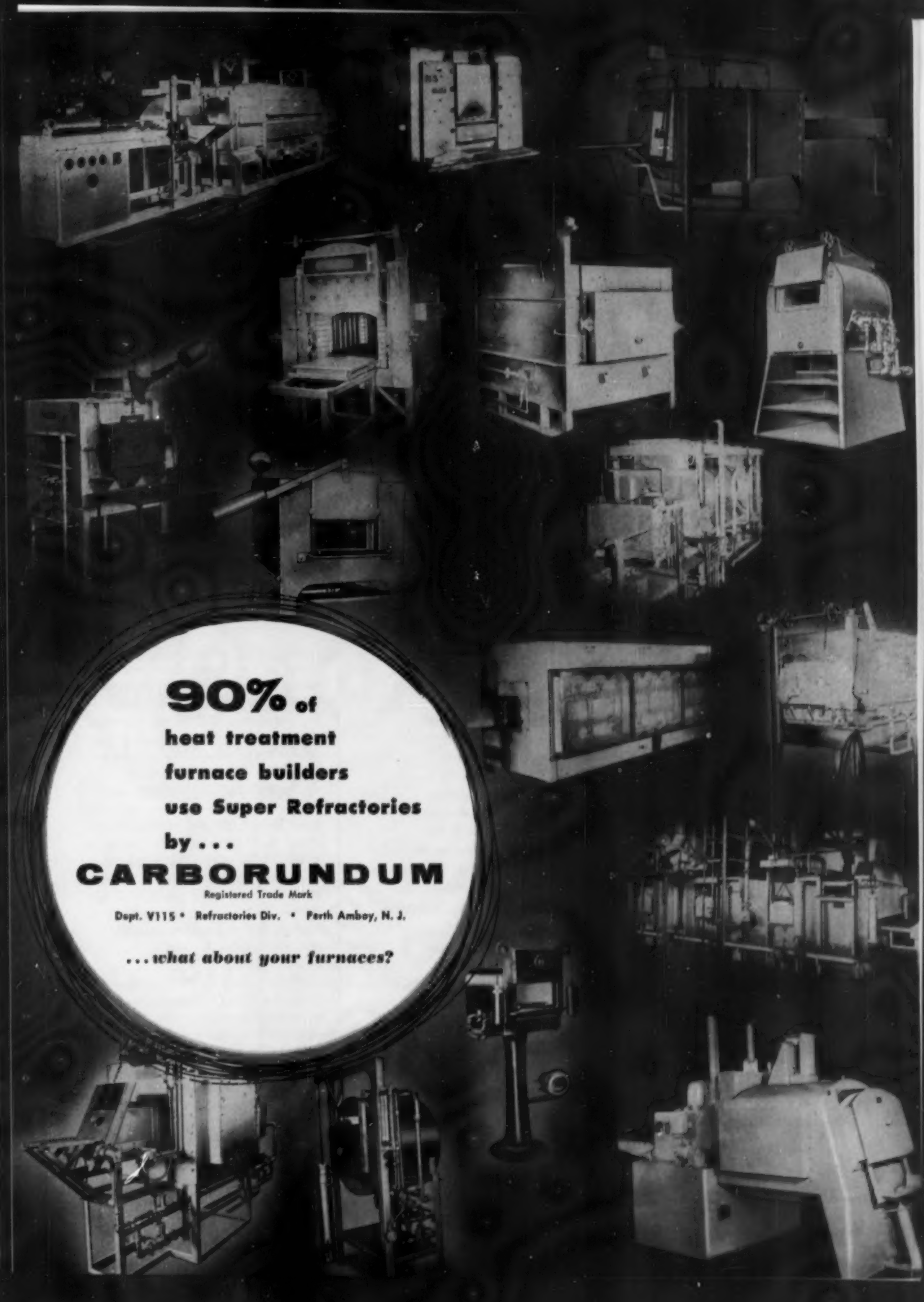
In 1830, a poor French tailor invented the first workable sewing machine. This great step forward in the garment industry was so feared that a mob wrecked the tailor's establishment and almost succeeded in murdering the inventor! Similar riots often occurred in England during the so-called industrial revolution.

Today, we smile at such fears. The sewing machine and the prime mover have saved billions of hours of hard toil. In the clothing industry it has resulted in increased production, increased employment, and more clothes for more people. The sewing machine is used all over the world, civilized and savage. Automation in general promises to repeat this kind of favor for mankind and to do it with a largess never before dreamed possible.

Automation, as we know it today, has reached us—or more correctly, we have reached it—in the nick of time. Without it the industrialists at this meeting in San Francisco believe that we would not be able to deliver to the American people those increasingly finer products, those entirely new inventions and developments that our past performances have led people to expect and which have made our present standard of living the highest in the history of mankind.

There is a basic rule of industry that has been proved over and over again—more efficient production means more and better kinds of jobs

(Continued on p. 176)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Automatic Production...

--if and when there are enough men and women to do the new jobs, properly trained.

This new world of automation will doubtless call for many types of skills that are unheard of today. Forward looking companies do not wait for these skills to be developed in sufficient quantities by outside sources. They help their workers through special schools and courses to acquire the skills that the new "automatic" operations require.

In the opinion of these speakers the real danger today is not unemployment, but quite the reverse. In the next 20 years the United States in all probability will face an increasing shortage of labor. The men and women who will do the work of the world for the next 20 years are now alive and it can be predicted quite accurately what the nation will have in the way of human resources. The population of the United States, which is now about 165,000,000, will rise to approximately 190,000,000 in the next ten years, and by 1975 it will be at least 220,000,000.

But while total population will be rising at this tremendous rate, the total working force will increase much more slowly, since the expanding population will largely increase the so-called "nonproductive age groups". The number of people between the ages of 20 and 65 – the age group which furnishes the working force – will increase by not more than 7,000,000 of whom only about 4,000,000 will be actually available for work. This means that if our standard of living is to continue to improve at the rate it has moved in the past quarter of a century we must increase production per worker by 40% within the next ten years.

These changes will have tremendous effects on all phases of business from handling office data through production to the merchandising of equipment.

Small business, particularly, must expect to be altered by the growing use of automation. Small business faces two alternatives. The first is to be caught flatfooted, forced to fight rear-guard actions, attempting to compensate for or to counter

(Continued on p. 178)

Automatic Production . . .

new competitive conditions. The second is to anticipate, through careful study of what is going on in the economy and in the particular industry, and to plan a realistic course, thereby gaining advantage of early action and having the best possible choice of minimizing likely competitive pressures. Small operations can usually change more easily than massive corporations.

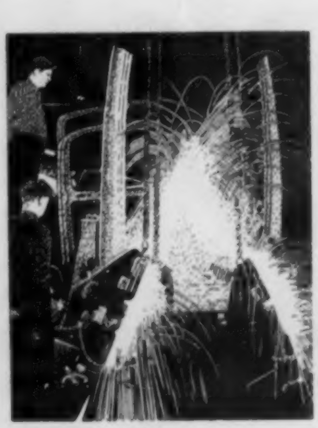
Because automation plays a major role in the modernizing of plants to meet the competition of streamlined new facilities, and because small business in the aggregate will contribute a healthy slice of the $27 billion being spent for plant equipment in 1955, there can be no question but that small business is taking the second course of action.

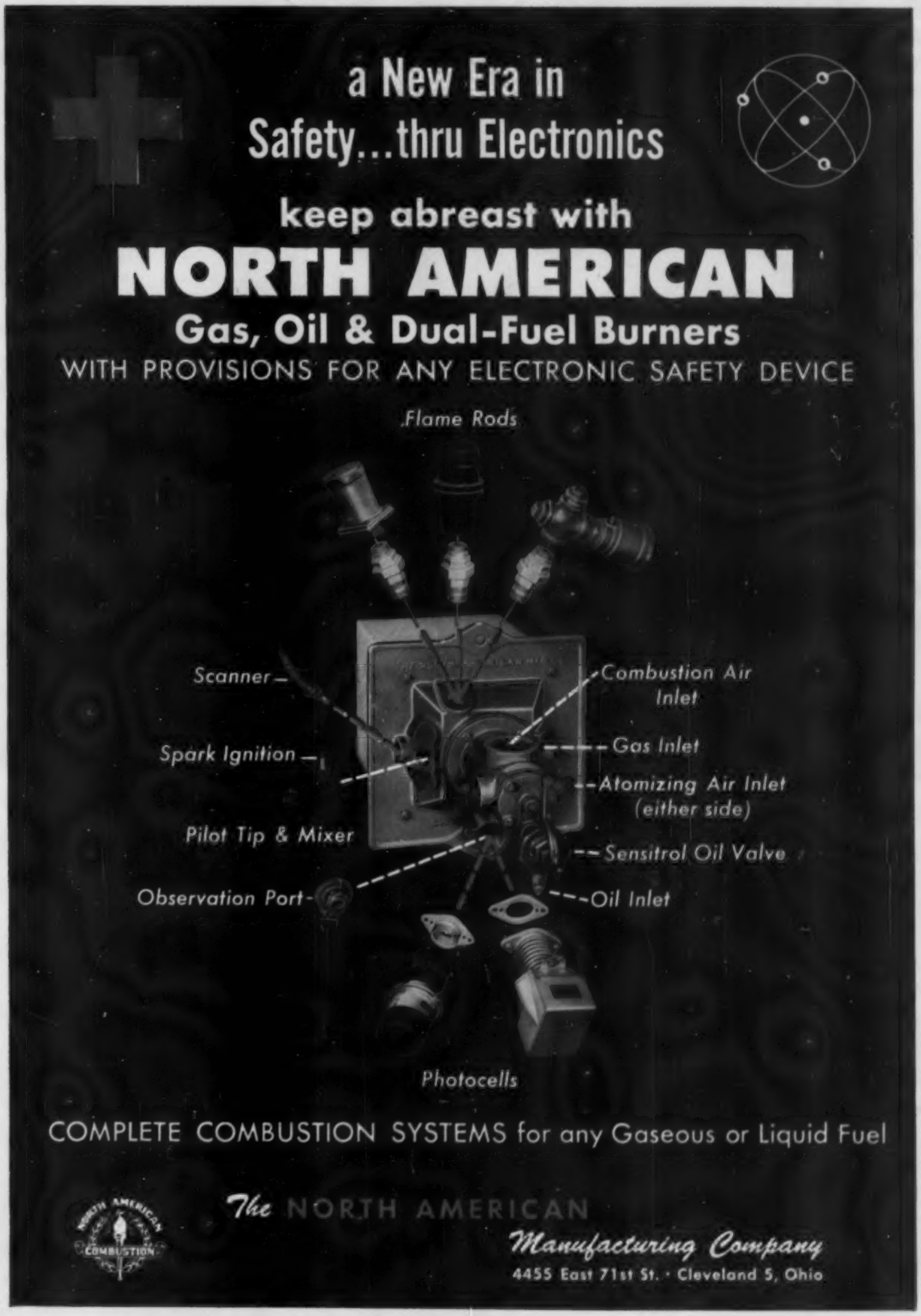
In the field of perishable food products, such as the production of bread, milk and ice cream, small business is the rule rather than the exception; and yet these plants are generally very highly mechanized.

While many of the larger companies already have large and competent staffs of technicians studying, devising, and recommending automation programs, the smaller companies cannot afford the luxury of such departments. But they do enjoy one conspicuous advantage other than adaptability. The growing number of companies that are in the business of producing automatic equipment are "small business", even though naturally they are interested in large-volume markets, as is everyone else. A quick look at the census of manufacturers tells any such manufacturer that the number of plants with less than 1000 employees is where the volume market lies. His urge, therefore, will be to design his wares to fit the needs of these more numerous small businesses.

The economic and social implications of automatic production are as broad as the economy and society itself. An interesting aspect of the international field is the possibility of automatic factories, powered perhaps by nuclear reactors, in underdeveloped areas. Assuming the availability of a small force of technical personnel to maintain and supervise such a plant, it is conceivable that production techniques could be elevated from primitive to advanced levels in a very short period of time. If an immediate source of raw materials were available and a mass market existed, such an enterprise might make good economic sense. In fact, it is likely that technical assistance is the prime necessity for the utilization of power in such areas. The future possibilities for technicians and engineers seem unlimited.

DAN WHITE

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High-Strength Steels for Welding*

During the last war a high-strength, low-cost steel containing about 0.23% C and 1.5% Mn, with yield stress of 45,000 to 58,000 psi., was extensively used for welded structures. It is subject to cracking in the heat-affected zone near a weld, and higher strength is also desirable. Welding cracks have been found less serious in thinner sections, with lower alloy contents, with low-hydrogen electrodes, and in steels having a high transformation temperature. Three classes of weldable steels with high yield strength in thick sections are discussed.

Conventional low-alloy steels with yield strength up to 67,000 psi., usually have less than 0.2% C to raise the transformation temperature, and 0.1 to 0.3% Mo to suppress the transformation to pearlite and restrict grain growth in the heat-affected zone. Such molybdenum steels should be tempered at about 1150° F. if a high proportional limit is desired. Tempered ½-in. plates of these molybdenum steels have 85,000 to 87,000 psi. tensile strength, 62,500 to 65,000 psi. yield strength, and good weldability in thick sections without preheat using low-hydrogen electrodes. With 0.08% V the strength is about 10% higher, but the weldability is worse – no better than that of the original manganese steel. The tempering treatment generally applied to the molybdenum steels raises the room-temperature Izod value from 30 to 90 ft-lb., improving the resistance to brittle failure.

The second class of newly developed low-alloy weldable steel contains still lower carbon with molybdenum and a little boron. A typical composition is 0.11% C, 0.55 Mn, 0.49 Mo, and 0.004 B. The weldability is excellent under all conditions with no preheat and almost all types of electrodes, and the yield strength is 71,500 psi. Due to the alloy contents and low carbon the

(Continued on p. 182)

*Digest of "Developments in Low-Alloy Steels for Welded Structures", by C. L. M. Cottrell, *Alloy Metals Review* (High Speed Steel Alloys, Ltd., England) Vol. 8, June 1955, p. 2-6.

Steels for Welding . . .

transformation temperatures are high. It has high strength in spite of low carbon. The room-temperature Izod value of ½-in. plates of this steel is 50 ft-lb., which is considered satisfactory.

The third class of steels, only briefly discussed, is supplied in the quenched and tempered condition, but apparently is not used commercially in England. An example derived from a U.S. Steel Corp. publication contains 0.15% C, 0.75 Mn, 0.8 Ni, 0.5 Cr, 0.45 Mo, 0.3 Cu, 0.05 V and 0.003 B. After heat treatment it has a tensile strength of 105,200 psi. and yield strength of 89,600 psi. The weldability is very good and the ductility transition temperature is below −150° F. unwelded, and below −60° F. welded. Such quenched and tempered low-alloy structural steels should be very useful in the future because they combine so many desirable mechanical and metallurgical features; however, abnormally large heat treating equipment will be required. In the absence of such equipment, the molybdenum-boron steel with low carbon seems to be most promising.

George F. Comstock

Editor's Comment: Steels of the third class retain enough of their heat treated properties after welding so that the "abnormally large heat treating equipment" is only needed by the steel mills.

Desulphurization of Molten Pig Iron*

Transfer of sulphur from carbon-saturated iron to a 50% CaO, 50% Al_2O_3 slag was studied at 2740° F. It was found that the deoxidizers Si, Mn and Al increase the rate of desulphurization.

For each experiment the 50% CaO, 50% Al_2O_3 slag was melted in a large mullite tube and brought to temperature. A small graphite crucible con-

(Continued on p. 184)

*Digest of "Desulphurization of Carbon-Saturated Iron; Influence of Silicon, Manganese, and Aluminium," by E. T. Turkdogan, R. A. Hancock, and J. Pearson, *Journal* of the Iron and Steel Institute, Vol. 179, April 1955, p. 338.

Desulphurization of Pig

taining 8 g. of the master alloy (1.08% S and 4.2% C) was then heated to 2740° F. and centered inside the larger mullite tube containing the molten slag. A push rod then raised the large container so molten slag flowed into holes in the graphite crucible containing the high-sulphur metal. In a definite time this reaction crucible containing the molten metal and slag was withdrawn, quenched in water, and the sulphur content determined.

From theoretical considerations it is to be expected that deoxidizing elements like carbon, silicon, manganese, aluminum or titanium should increase the rate of desulphurization, because they lower the activity of oxygen in iron. The experiments verified this expectation. However, because of the sluggishness of the reaction between carbon and oxygen, carbon dissolved in iron or suspended in slag does not speed the rate at which sulphur is transferred from metal to slag as much as might be expected from thermodynamic considerations.

The transfer of sulphur from metal to slag across the interface is accompanied by a transfer of iron, manganese, or similar cations from the metal.

If the desulphurizing reaction takes place in a graphite container there is carbon suspended in the slag. This is oxidized by the slag, resulting in the formation of metallic iron, which can be in a very fine state of subdivision.

If no reduction takes place in the slag, an ion of oxygen is transferred from slag to iron for each ion of sulphur passing into the slag layer.

E. C. Wright

Atomic Factories . . .

(Continued from p. 117)

pushed in the entrance to a channel in the front face; all the cartridges already in the channel move along and the one at the farther end falls out and drops straight down into a deep water channel which acts as a radiation shield.

Extreme precautions were taken during construction to avoid contaminating the thousands of tons of purified graphite going into the piles as "moderators". Machining was done under conditions of cleanliness comparable with those required in a surgical operation. The workers stripped to the skin and put on specially laundered clothes and special shoes. When the graphite core was built up inside the biological and thermal shields, incoming air was filtered and the workers again wore special clothes.

The two chimneys through which the cooling air is discharged are 40 ft. in diameter, 415 ft. high. Dust-free air is blown through the pile; circulation through the buildings is also of filtered air; both are exhausted through the stack. Radioactivity in the discharge is carefully monitored; any further chance that any radioactive dust might get out of the top of the stack is avoided by filters near the top. Likewise there is a gallery and an outside elevator shaft, completely enclosed, to replace dirty filter units.

The publication under review outlines the solvent extraction process adapted to separate the plutonium and fission fragments from the partly exhausted uranium slugs. The processes are continuous and remote controlled – no pumps, no valves, no filters; only columns, tanks, and miles of connecting pipes all completely shut away in a concrete box. Everything is of a new variety of stainless steel resistant enough to corrosion and stable enough against the intense radiation. Since plutonium is an intense chemical and radioactive poison it was vital to eliminate any possibility that it could escape from the plant, either in solution or as a dust. To aid in this, and to diminish the fire risk, the whole plant is operated in an atmosphere of inert gas.

It was, of course, essential in the completed equipment that all welds should be perfect. Each was first examined visually on both sides; if the joint was between two pieces of pipe then a long periscope, with an electric light at the end, was passed down the inside of the pipe to enable the examiner to look at the inner surface. The weld was then radiographed. Only when both visual and radiographic inspections had shown that the weld was perfect was the welder allowed to join another piece onto the same pipe. This rigorous inspection involved careful planning if welders were not to waste time. There are over 50,000 welds and 10 miles of pipe.

If the welding presented a problem, so too did welders. Even skilled and experienced welders had to be specially trained for this job. A special school had to be set up to train men in all branches of the art; about 100 men were trained in this manner.

Complete history required also

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that each billet of steel be accounted for; every piece of plate or pipe was given its identifying number. If the inspectors found any defect in any weld, every weld made in metal from the billet was immediately re-examined.*

U^{235} Factory at Capenhurst – This operates on the same principle of diffusion of gaseous compound (UF_6 or "hex") through a diaphragm as described in the Smyth report for the American plant at Oak Ridge. This process had, in fact, been under study by English scientists since early in 1941. Some principal requirements of the process are an efficient and long-lived barrier or diaphragm, extreme cleanliness of the gas in process to avoid closing the pores in the diaphragm, a vacuum-tight system (petroleum distillation, the nearest industrial process, can tolerate 500 times as much leakage), and corrosion resistant materials of construction. The document under review gives some information on methods of detecting, isolating and repairing leaks.

General designs were made early in 1948; work on the site began in March 1950; "part of the works is operating and producing a satisfactory output" (December 1953).

Power Developments – Long-term research is still essentially the responsibility of Harwell (which is not described in the present booklet†). The bulk of the research and development work is related to technical problems in metallurgy, applied physics, and chemistry arising in the design of new plants, as well as improvements in existing plants.

Staff problems have been important. Recruitment has been disappointing and frustrating more often from the lack of candidates up to the standard set than from any other cause. For some years the branch dealt with some 600 applications a month but the proportion of those considered suitable for appointment was woefully small.

The quality of the job has been assured by building up a first-rate design organization. Speed was attained primarily by placing responsibility for major units squarely on individual engineers and by streamlined planning and supply arrangements. The effectiveness of these measures was enhanced by the high degree of autonomy given to Risley in matters relating to finance, recruitment, accommodation, and purchasing. Moreover, great contributions have been made by all parts of the engineering and chemical industries in producing unusual materials and manufacturing awkward plant components and machines.

Some mention should be made of the uses of the product of these factories. One is for experiments into the properties of the elements and into the reactors in which they may be used as fuel. A second use is for the manufacture of weapons. A third

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*Editor's Footnote — If this scheme of identifying *each* piece of pipe had been in vogue in American practice, a million-dollar job of replacing mixed-up piping on the atomic submarine Nautilus would have been avoided.

†See "Harwell: The British Atomic Energy Research Establishment", published by Her Majesty's Stationery Office, Kingsway, London, W.C. 2. Price 6s net.

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application is to the generation of power for industrial purposes. This is very much the business of Risley and is engaging more and more attention. Especially is the aspect of "breeding" – the process of producing more plutonium-239 in a reactor burning plutonium, or more uranium-233 in a reactor burning uranium-233. This is due to the circumstance that, on the average, three neutrons are born in the thermal fission of Pu^{239} and only one is needed to maintain the chain reaction. Theoretically, the other two are available to combine with U^{238} and transmute or convert it to Pu^{239}. Such breeder reactors may be described as converters.

Heat generated in the converter must be carried away. Various heat transfer systems are being studied at Harwell, and one of the most promising is the use of molten metals, such as a molten alloy of sodium and potassium. Gas under pressure is another possibility. Whichever coolant is used, it is likely that it will be passed through a heat exchanger where the heat will be transferred to water to produce superheated steam; this steam will then be used to drive steam turbines or other machinery. The extensive studies at Harwell and Risley have convinced scientists and engineers that nuclear energy should be able to make a substantial contribution to the electricity supply of the country at a cost comparable with the cost of coal-generated electricity.

In fact, if certain assumptions turn out to be valid, it might ultimately be possible to replace coal completely by nuclear fuel for the generation of electrical power in the United Kingdom. Our total requirements are likely to increase to an annual rate of 63 million tons in the next 15 years. When one remembers that it becomes yearly more difficult to maintain, let alone increase, the output of coal from British mines, it becomes clear that a saving of this magnitude would transform the nation's economy.

A more immediate objective, one that might possibly be realized within 20 years, would be to set up a reactor system which would generate enough electricity to produce a

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XII

This is the twelfth of a series of advertisements dealing with basic facts about alloy steels. Though much of the information is elementary, we believe it will be of interest to many in this field, including men of broad experience who may find it useful to review fundamentals from time to time.

Vanadium Alloy Steels and Their Uses

Though the beneficial effects of vanadium in alloy steels have been known for many years, the ore was at one time a comparative rarity. Vanadium is still rather expensive because of the care required in processing the ore; however, there are now ample supplies for present-day applications.

Vanadium is a highly valuable alloying agent. It is an extremely powerful deoxidizer, though seldom used primarily for that purpose. Vanadium also tends to form stable carbides in steel—carbides that do not go readily into solution when heated above the critical temperature for quenching. The grain-growth-inhibiting effect of vanadium promotes a fine-grained structure over a fairly broad quenching range, thus imparting strength and toughness to the heat-treated steel. Moreover, the carbides are not prone to agglomerate during the tempering operation.

Vanadium is used in constructional steels, not only to refine the grain, but to improve the mechanical-property balance. Generally speaking, the amount of vanadium in constructional steels ranges from approximately 0.03 to 0.25 pct, though larger quantities are required in tool steels and special analyses.

A list of products containing vanadium would include certain types of spring steels, plates, gears, high-temperature steels; forged axles, shafts, and turbine rotors; and other items requiring impact- and fatigue-resistance.

You are invited to consult with our staff whenever you need information about vanadium steels. Bethlehem metallurgists will gladly advise you regarding analyses, heat-treating, machining, and anticipated results. Please remember that the services of these technicians are yours for the asking, and that no obligation is implied.

And may we point out, too, that Bethlehem makes all AISI standard alloy steels, as well as special-analysis steels and the full range of carbon grades. Call upon us for your alloy steel requirements; now and always, we will endeavor to meet your needs promptly.

If you would like to have a reprint of this advertisement, or of the entire series from I through XII, please write to us, addressing your request to Publications Dept., Bethlehem Steel Company, Bethlehem, Pa.

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BETHLEHEM STEEL

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saving of 20 million tons of coal a year, the amount by which estimated production will fall short of estimated consumption during the next 15 to 20 years, by building power-converter thermal reactors, using natural or slightly enriched uranium. By that time efficient power breeders will have been developed to the point at which they can be built in numbers great enough to achieve the ultimate goal – the generation of all the country's electricity; these units would be fueled initially with the plutonium produced by the power converters.

[A "provisional" program has already been adopted by the Government of the United Kingdom, calling for the construction by 1965 of 16 reactors to produce about 1750 megawatts of electricity at a cost of about $850,000,000. This will represent about one quarter of the total needs of *new* generating capacity in the next decade. Gas will be used as a heat transfer medium in the first two to be built; they will use graphite as a moderator. Cost of electricity for these first stations is estimated at about 7 mils per kw-hr. – about the same as a new coal-fired central station.]

Refractories for Induction Melting of Cu*

THREE decades of production experience with the low-frequency induction furnace for melting copper and copper alloys have seen progressive improvements in lining construction and materials with longer life and freedom from operational difficulties. In early years the furnace was suitable for melting only brasses containing a maximum of 70% Cu. Even with these alloys tonnage per lining was only 75 to 375 for a 30-kw. furnace. Today, linings can be counted on to last for thousands of tons of brass as well as other copper alloys with higher melting points. *(Cont. on p. 194)*

*Digest of "The Use of Refractories in Low-Frequency Induction Furnaces for Melting Copper Alloys", by Maurice Cook, C. L. M. Cowley and E. R. Brondfield, *Journal of the Institute of Metals*, Vol. 83, February 1955, p. 295-305.

Refractories . . .

Principal refractory problems in the furnace are centered in the transformer unit below the hearth line. This element is essentially a refractory block with an open-ended secondary channel and a central opening of relatively large diameter in which the primary coil is positioned. The secondary channel is normally U or V-shaped, ranging in cross-sectional area from 2.5 to 5.5 sq. in. Its section may be oval, circular, rectangular or a combination of these. For close magnetic coupling the channel is located as near to the primary coil as possible, minimum distance being about 2¼ in. for a 600-lb. per hr. furnace and 2¾ in. for a 2400-lb. per hr. unit. Thinness of this shell necessitates high resistance to metal penetration, good insulation properties to avoid heat losses and high electrical resistance to maintain current efficiency. Thermal gradient through the shell is on the order of 1800° F.

The cross-section area of the secondary channel must remain fairly constant in operation. This can be realized only with a refractory resistant to spalling and erosion or chemical attack by metal oxides in the melt.

No single refractory has yet appeared with all the desired properties. Those most economically and physically suited are mixtures of silica and certain of the aluminosilicates. The siliceous type, usually containing about 90% silica in the form of crushed and graded but uncalcined quartzite mixed with 15% uncalcined clay, are used mainly in linings of furnaces for melting phosphorus-deoxidized copper, cupronickel and nickel silvers. The aluminosilicate mixtures, consisting of calcined, crushed and graded fireclay base, possibly with some alumina and 15 to 20% uncalcined clay, are found extensively in furnaces for melting copper-zinc alloys and brasses with small additions of such elements as Pb, Sn and Al.

Refractories of high alumina content, although they have good resistance to attack by copper-rich alloys, are not favored because of high initial cost and susceptibility to cracking. Fused and ground magnesia is also costly and will spall.

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Refractories . . .

Recommended method for construction of good linings is to ram the moistened powdered refractory mix into a monolithic block around forms of suitable size and shape. While simple and convenient, the technique calls for considerable care in holding uniform moisture content (about 6%) of the mix and in proper manipulation of ramming tools.

Wood forms are used in ramming the secondary channels. They are frequently hollow and internally threaded with a strip of resistance wire so they can be burned out and the refractory around the channel dried. A newer method of construction involves the use of prefired refractory tubes instead of wood forms. They are available in a variety of materials such as sillimanite, alumina and silicon carbide. With a 1-in. wall thickness, they are sufficiently strong to withstand ramming pressures of 80 to 90 psi.

Linings are dried at room temperature for about three weeks, then heated to near the molten metal temperature with gas burners and finally primed with molten alloy. Service life is closely related to the melting rate and furnace capacity. Higher melting speed naturally shortens lining life. The average life of a 2000-lb. brass furnace lining may be nearly four times that of a lining in a furnace with half that capacity.

Lining failures generally are associated with construction techniques or operational factors such as reactions between refractory and melt. The former may include incomplete bonding of adjacent ramming layers, inadequate ramming, too rapid drying or an excessive temperature differential between lining and melt when the furnace is primed. Operational improvements contributing to longer life of linings have been the standardization of charging methods, adoption of controlled melting rates, temperature control during melting and adequate attention to the details of fluxing, skimming, pouring and furnace cleaning.

Melting of cupronickel and nickel silver in siliceous refractories is accompanied by formation of a fluid reaction product due to the presence of manganese. The oxide reacts

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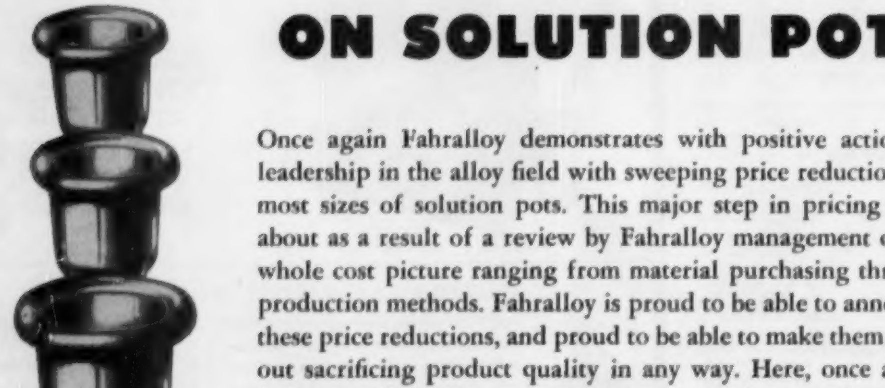

Once again Fahralloy demonstrates with positive action its leadership in the alloy field with sweeping price reductions on most sizes of solution pots. This major step in pricing came about as a result of a review by Fahralloy management of the whole cost picture ranging from material purchasing through production methods. Fahralloy is proud to be able to announce these price reductions, and proud to be able to make them without sacrificing product quality in any way. Here, once again, is clear evidence that proves why you can always look to Fahralloy for leadership in the alloy field. Send for a firm quotation today.

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Refractories . . .

readily with silica to form the eutectic $MnO \cdot SiO_2 + 2MnO \cdot SiO_2$. It proceeds more rapidly in the cupronickels because of their higher melting temperatures and also because of their higher manganese content. It is not unusual for the section area of the secondary channels of furnaces handling cupronickel to enlarge from about 5.5 sq.in. to as much as 35 sq.in. by the time the furnace is decommissioned.

A. H. ALLEN

Combustion Systems . . .

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Furnaces heated with radiant tubes are used extensively in sheet and tin-plate departments—for example, in the cover type of annealing furnaces described by Fred Olmstead on p. 91. The principal reason is the accurate location of the heat source in an operation wherein distribution is the demanding factor. Its disadvantage is the inability to get sufficient heat transfer surface in the proper location to satisfy some operators.

Throughout the steel industry, there are of course many heat treating furnaces of the direct-fired type. These take the form of roller bottom furnaces, car type of annealing furnaces, cover type of coil annealers, and pit type for heating long forgings. The purpose of the combustion system in these furnaces is to provide uniform temperature and an atmosphere which will not damage the surface beyond correction in subsequent descaling or pickling operations. Their combustion systems are less complicated than in the high-production furnaces of the heavy steel mill. Instruments to control furnace pressure and fuel-air ratio are seldom installed. The "tempered flame" burner is extensively used, wherein the fuel input is varied while the air stays constant.

Conclusion – All in all, the many problems involved in the design of modern and efficient combustion systems for the steel industry have been so successfully solved that we are now a long way from the place where a furnace was defined by a veteran steelmaker as "a coupla burners and a pile of bricks"!

STATEMENT OF THE OWNERSHIP, MANAGEMENT, CIRCULATION, ETC.

Required by the Act of Congress of August 24, 1912, as amended by the Acts of March 3, 1933, and July 2, 1946 (Title 39, United States Code, Section 233) showing the ownership, management and circulation of **Metal Progress**, published monthly at Cleveland, Ohio, for October 1, 1955.

1. The names and addresses of the publisher, editor, managing editor, and business managers are: Publisher, American Society for Metals, 7301 Euclid Ave., Cleveland 3, Ohio; Editor, E. E. Thum, 7301 Euclid Ave., Cleveland 3, Ohio; Managing Editor, M. R. Hyslop, 7301 Euclid Ave., Cleveland 3, Ohio; Business Manager, W. H. Eisenman, 7301 Euclid Ave., Cleveland 3, Ohio.

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3. The known bondhonders, mortgagees, and other security holders owning or holding 1 per cent or more of total amount of bonds, mortgages, or other securities are: None.

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5. The average number of copies of each issue of this publication sold or distributed, through the mails or otherwise, to paid subscribers during the 12 months preceding the date shown above was: (This information is required from daily, weekly, semi-weekly, and tri-weekly newspapers only).

E. E. Thum,
Editor.

(Seal)

Sworn to and subscribed before me this 23rd day of September, 1955.

Ray T. Bayless,
Notary Public.

(My commission expires May 19, 1957.)

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